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ADDRESS AT THE ANNUAL GENERAL MEETING

of the Society, held on 25 June 1945, by the President

THE RIGHT HON. SIR GEORGE CLERK, G.C.M.G., C.B.

AT our last Annual Meeting I expressed a modest hope that within a year some of the difficulties with which we were faced might no longer hamper our work. This hope has been to some extent fulfilled, and the Council at their first meeting after the victorious conclusion of the war in Europe ventured to submit a resolution of loyal congratulations to His Majesty The King, Patron of our Society. I am permitted to say that His Majesty much appreciated this message. Restrictions of every sort and kind do, alas, still remain, as most of us are painfully reminded every day, but we can at least now look forward to resuming the varied normal activities of the Society, which have necessarily been curtailed in the last five years.

I might perhaps say that a first and happy instance of this renewal of our normal activities has been the award this afternoon of the Patron's Medal to Sir Halford Mackinder. I hope that next year my successor will have the pleasure of announcing a full list of recipients of our Gold Medals and other Awards.

We have suffered a number of heavy losses in the past year particularly among those closely identified as Officers or Members of Council with the work of the Society. Admiral Sir William Goodenough was President during the years 1930–33, an important period in our history, when we were settling into the new building and possessed for the first time a lecture theatre of our own: he continued to serve assiduously as Vice-President or on the Council until his death. Few had had a longer connection with the Society; well known to many Fellows, it is unnecessary for me to enlarge upon his very distinguished naval career, his many and varied interests, and the time and attention he gave to promoting the welfare of our Society. I would like however to emphasize one aspect of his work; the pains he took to foster the spirit of adventure and to give youth every support and encouragement in proving itself in the field of exploration. No one has a greater claim to be held by us in lasting and loving memory than William Goodenough.

William Lutley Sclater was killed by enemy action in July last year, not long after he had retired from the office of Honorary Secretary. This office he had occupied with efficiency and distinction for thirteen years. For it he was well equipped by extensive travel, largely in pursuit of his ornithological researches, by his sane judgment, sincerity, and kindliness. Entirely self-effacing and free from self-assertion, the value of his work for the Society might easily be overlooked by those who did not know him intimately. He was in truth one of those Fellows to whom we owe an especial debt of gratitude.

Another Member of Council whose loss will be much felt is Air Chief Marshal Sir Charles Burnett. His distinguished career in the Royal Air Force in the critical years before 1939 has earned for him the deep gratitude of the nation. When his official duties permitted, he had served at intervals upon the Council and on the Finance Committee, where his judgment was greatly appreciated.

Lord Moyne, who died in Cairo at the hands of an assassin in November, had served our Society well as Vice-President and Member of Council. I have given in the *Geographical Journal* some account of his very distinguished work in the service of the State and in the cause of science. He was privileged to pursue his geographical and scientific interests on an unusual scale, and the generous disposition of his collections has enriched many institutions in this country. In him we have lost one who was intent upon extending our knowledge of the world, who took pride and pleasure in our Society and in furthering its aims, and, though we owe him much, our debt would have been even greater had he been spared.

Through the death of Mr. A. R. Hinks the Society has been deprived of one who had served it faithfully and with great distinction for many years. Mr. Hinks was appointed Assistant Secretary in 1913, and two years later succeeded Sir John Scott Keltie as Secretary. His thirty years' tenure of office therefore coincided with our occupation of Lowther Lodge. During that period he was responsible for the administration of the Society, the conduct of day to day business, the editing of the *Geographical Journal* and other publications, and for advice and assistance to travellers and students. To all of these activities he brought great powers of organization, a capacity for grasping readily the fundamentals of a problem, and wide scientific ability. In this necessarily brief appreciation I would mention his contribution to the science and art of map making, his work upon the subject of map projections, and his persistent advocacy for the applications of modern advances in scientific technique to survey. As an exponent of the highest standards in the design and lettering of maps, he has left his ineffaceable and characteristic impression upon British cartography. We should especially recognize to-day his devotion to duty, a devotion which undoubtedly contributed to his last illness.

Of the other distinguished Fellows whom we have lost in the past year there are some whom I would particularly mention. Lord Lugard, a Gold Medallist of the Society, has left one of the greatest of British names in our African record, a name that will ever be closely associated with the foundation and development of our colonies in West Africa. Sir Charles Bell had travelled extensively in Central Asia, Bhutan, and especially in Tibet, where he had

carried out important political missions. He was a recognized authority on the history and language of that country. Sir Eric Teichman was another authority on Central Asia. A member of the diplomatic service in China for many years, he had made several journeys through the Chinese–Tibetan marches, in Eastern Turkistan, and across Central Asia. In 1936 he gave us an illuminating account of his journey from Peking to Kashgar. At the time of his death, Sir Douglas Newbold was Civil Secretary in the Government of the Sudan. He had carried out two important pioneer journeys in the Libyan Desert, the history and archaeology of which he had made his particular study.

Brigadier-General Sir Percy Sykes, who died very suddenly a fortnight ago, was well known to us for his many journeys in Persia and Central Asia, and for his books on the history of that region. His achievements in the field were recognized by the award of our Patron's Medal in 1902. He had been a Fellow for over fifty years, had served for several terms upon the Council, and was always keenly interested in the progress of the Society.

Squadron-Leader Michael Spender, who died after a flying accident in the closing hours of the war in Europe, was a specialist in photogrammetric survey, with a particular knowledge of continental methods. He had taken part in expeditions to the Great Barrier Reef, East Greenland, Mount Everest, and the Karakoram Himalaya, and for a period served as a research assistant on the Society's staff. During the war he carried out valuable work for the intelligence services.

The Society's staff has suffered another loss in Corporal F. Potty, Map Mounter, who was accidentally killed in Holland last October.

Last year I referred briefly to the damage which our House had received as a result of enemy activity. To-day we can be thankful that we escaped so lightly, and it is now only a question of "priorities" before our House will be completely restored.

By this time next year my successor will, I hope, be able to lay before you a general account of the geographical knowledge acquired during the years of war. There are however two notable achievements of the current year to which I should refer, and incidentally they exemplify contrasted methods of Arctic exploration. Last year Sergeant Larsen, of the Royal Canadian Mounted Police, who had previously in the *St. Roch* made the first west to east navigation of the North-west Passage, completed a voyage from east to west in one season, and by a new route, an achievement upon which the Council were happy to congratulate him, and of which we shall publish an account in our *Journal*.

The successful flights of the *Aries*, under the command of Wing Commander D. C. McKinley, over the geographical and magnetic North Poles, are from many aspects a most notable achievement. The bearing of the results obtained on the main air routes of the future is obvious, though it may be some time before these will cross the Arctic. The navigational methods employed are a subject in which this Society, and particularly our late Secretary, has taken much interest. We congratulate most cordially Wing Commander McKinley and his crew on this fine achievement, and I am glad to

say that during the coming Session we shall have the opportunity of hearing a first-hand account of these flights.

The Fellows will also, I think, be glad to know that we have had the pleasure recently of welcoming Major Patrick Clayton, one of our Gold Medallists, well known for his work in the Libyan Desert, and recently a prisoner of war in Italy and Germany; and that Lieut.-Col. F. Spencer Chapman, now, I am glad to add, D.S.O., to whom I referred last year, is returning to this country after three years' special service in Malaya.

During the past year, despite the accumulation of difficulties arising from war conditions, the strength of the Society has been well maintained, and we have had a number of varied and excellent papers. Five years ago the general uncertainty was naturally reflected in a decline in the Fellowship, but this has happily now been arrested. In each of the two consecutive years 1943 and 1944 we have recorded a net increase in the number of our Fellows, the first since 1938, and there is every indication that this upward trend is continuing, a most hopeful augury for the future.

Owing to the depletion of the staff of our printers, and the priority accorded to official work, it has unfortunately not been possible to keep the publication of the *Geographical Journal* up to date. The Council are of course cognizant of the important place which the *Journal* occupies in the Society's work, and every effort will be made to recover the lost ground as soon as possible.

The decision made in 1939 to carry on the work of the Society in London as long as possible, and not to evacuate our important collection of books and maps, has been thoroughly justified. Great use has been made of them by Service and Government departments, and by officers of the Allied nations, while the requirements of Fellows have been met throughout.

The Council have been notified of a most generous benefaction which will shortly be received by the Society. Under the will of Mrs. F. E. Andrews, the widow of Mr. Michael Andrews, a Fellow of our Society, the residue of her estate is left, in accordance with her husband's wishes, to promote the study of cartography. This will permit the foundation of a substantial studentship, and I wish to express our deep appreciation of this important benefaction.

Another bequest under the will of the late Lady Owen-Mackenzie, in memory of her brother, Major Roddy Owen, has been received during the year, as well as several generous gifts to the funds of the Society, for all of which the Council have expressed their grateful thanks.

At our Meetings the lecturers have dealt with a variety of subjects. Lord Rennell has described the geographical background of the former Italian possessions in East Africa: we have learnt of the effects of the war in two contrasting regions, in the Hadhramaut from Mr. and Mrs. Harold Ingrams, and in Szechwan from Dr. H. L. Richardson. The application of geographical knowledge to military requirements was vividly demonstrated by Brigadier Bagnold's account of the early work of the Long Range Desert Group in Libya. Mr. Christopher Sandeman described his journey along the Amazon headwaters in Peru, and Dr. J. V. Harrison his journeys in little-known Luristan. The centenary of the sailing of Sir John Franklin on his last expedition was fittingly marked by two valuable papers by Dr. Richard Cyriax and Mr. J. M. Wordie. The problems presented by one aspect of planning, the

treatment of our mineral resources, were admirably dealt with by Mr. S. H. Beaver; and Dr. Dudley Stamp advanced a challenging interpretation of the geographical history of the North Sea and the Strait of Dover. Other technical subjects treated have included the value of air photographs in archaeological research, the influence of rock flow upon topographical features, and the stability of natural slopes. Lieut.-Col. E. H. Thompson has also described to us an ingenious instrument for the determination of position, invented and produced by him for the Long Range Desert Group. We had the privilege of welcoming a distinguished American visitor, Mr. Russell Lord, who gave us an eloquent account of the measures taken to repair the ravages of soil erosion in the United States. We have also been fortunate in having had the opportunity of seeing several remarkable colour films, such as Mr. Hope Gill's films of the Hadhramaut and Ethiopia, Sir Basil Gould's beautiful film of the enthronement of the Dalai Lama, with Colonel F. M. Bailey's commentary, and Mr. William Courtenay's film of the operations in the Pacific.

Fellows will realize that the preparation for all these lectures, the maintaining of the facilities of the Society for Fellows, and general conduct of its affairs have thrown upon a war-depleted staff an immense amount of additional work. Where all those connected with the Society have faced up to the difficulties so zealously and efficiently, it is almost invidious to single out any individual for special comment, though there are many of whose work I should like to say a special word. I feel however that I cannot do better than to express to the whole staff under, since the lamented death of Mr. Hinks, the guidance of our Librarian, Mr. G. R. Crone, the high appreciation of the Fellows of the Society and, if I may do so, my own very warm personal thanks for their encouraging help and loyalty.

So much, Ladies and Gentlemen, for what I may perhaps call my official summary of the year's proceedings of the Society. As this is the last time that I shall have the honour of addressing you from this Chair, I should like, if I may, to end with a few words of a more personal nature.

The strength of the Society's Fellowship and the frequent inquiries on the opportunities for exploration and geographical research which we receive bear witness to the widespread and increasing interest in our subject. The reasons for this are clear. Hundreds of thousands of men and women have found themselves in strange and interesting environments, which have awakened a taste for exploration or further knowledge in the more adventurous and thoughtful. Again, the course of events has brought home to many the close relationship between geography and national life. Examples of the practical application of geographical knowledge will occur to us all—in the desert campaigns of North Africa, in the preparations for the invasion of Europe, in the establishment of land routes into China. As a result of recent developments in communications, the exploitation of new sources of supply, the industrialization of new areas, and the redistribution of population, the geography of the world is being profoundly altered.

Clearly there will be no lack of material for geographers, and it will be for our Society to encourage and direct this enthusiasm to profitable ends in the coming years. The extent to which it is possible for us to do this depends ultimately upon the strength of our Fellowship, and I trust that Fellows will

lose no opportunity to make known the work of the Society and to secure the active interest of suitably qualified men and women. We are desirous of being in a position adequately to support the resumption of exploration and scientific research in the field, and I would commend to your generosity the Society's Expedition Fund.

From time to time comments are made upon the status of geography in this country. It has been said that, compared with other scientific studies, geographical research enjoys a lesser standing or is less amply endowed. I do not propose to examine these charges in detail, but would make clear the Society's position. In the past the Society has done much to advance the cause of geographical education, having contributed, incidentally, at least £20,000 from its own resources to this end, and there are now a number of Chairs of Geography in British Universities. What the Society has done in the past, and will continue to do, is to provide a common meeting-ground for geographers, whatever their special interests, and to keep the importance and attractiveness of geography in the public attention. Our Society offers to those interested a means of supporting and encouraging exploration in the widest sense as the foundation of all geographical knowledge. Similarly, while not undertaking the direction of research, the Society has encouraged it so far as its resources permit.

There is great work awaiting the Society and in the person of the distinguished Gold Medallist, whom the Council propose to you as my successor, you have one who is in every way qualified to undertake this charge. It may be that geographical exploration as applied to the actual surface of the globe is more or less at an end, but that, important and essential though it is, is only a first stage in the science and study of geography. Oceanography, atmospherics, the terrifying movements of the earth beneath our feet, the various types of avalanches, the slow but insatiable encroachment of the great deserts, the folly of mankind in deforestation and overcropping and scraping off the surface of the soil for immediate profit, are all subjects for the deepest study and research on the part of geographers, and I am confident that our Society will continue to foster and encourage such study and to hold its high and honourable place in the geographical and economical development of the world in which we live. It is a stupendous task but I know that my successor and those who come after him will, with your support, prove themselves fully worthy of it and of our century-old reputation.

In conclusion I want to say how greatly honoured I have felt in holding the high position of President of the Royal Geographical Society during these difficult years. There have been great men among my predecessors and there will be more among my successors, but none more conscious of the Society's interests. May I thank the Officers and Council and whole body of Fellows of the Society for the patience and courtesy with which they have suffered my presidential shortcomings. I can only say in my defence that during my term of office I have endeavoured to serve the Society to the best of my humble capacity.

PROGRESS OF SOIL CONSERVATION IN THE UNITED STATES

RUSSELL LORD

Afternoon Meeting of the Society, 30 April 1945

IN asking that I tell you something about the movement toward improved soil conservation in the United States, you do my country an honour only recently deserved. Ten years ago we should have had little that was hopeful and much that was shameful to report.

We Americans are inclined to do things suddenly. Only yesterday in terms of historic time the North American continent was an Indian paradise. Here was a vast and fruitful land, clad with a robe of plants that had protected it for millions of years. Suddenly this body of land was thrown open to land-hungry immigrants from Europe. With a rush we took it and beat upon it hungrily, wave by wave. Our exploration and exploitation of one new strip of the West after another proceeded with frantic haste. First the Atlantic plain and the Piedmont plateau were taken, then the Allegheny headland and the Land of Western Waters, then the prairie and all the great central valley, the Great Plains and the West Coast, and finally the rough high inter-mountain country back from the Pacific shore. We new Americans had no longer an unspoiled reserve of land.

By the beginning of the present century the hard fact of diminished basic resources had forced us to slow down on plunder and to take stock. By 1910 natural-born prophets of a more reverent and provident husbandry, men like Gifford Pinchot and Liberty Hyde Bailey and Theodore Roosevelt, were crying ruin. Before he died in 1916, Henry Wallace, grandfather of the present Henry, preached mighty sermons pleading for better care of what he always called "the voiceless land." Our conservation movement started then, some thirty years ago. But in the heat and excitement of the first World War we surged out again and dealt more wounds to soils already diminished in productive vitality. It was not until the administration of a second Roosevelt, Franklin Delano Roosevelt, that our people were led to make the turn toward a permanent and decent use of land, water, trees, wildlife, and all the naturally renewable sources of an enduring civilization.

Suddenly, then, we seized upon and bared American soil for what we called "cultivation." In countless places we thinned our topsoil to half or less than half its former depth and productivity. And now, even more suddenly, we have undertaken to reform. In the course of this hour I shall hope to indicate the present extent of an agricultural reformation which is plainly visible and measurable in terms of fields and yields. But more than that I want to tell you that in the process of making these physical changes upon the face of our country we Americans have experienced a continuing change of mind and heart.

The late Seaman A. Knapp, a great agricultural teacher in our South, used to argue for learning to do by doing. He argued for the demonstration or action method as opposed to academic rote or preachment. "What a man

hears he may doubt," he said. "What he sees he may possibly doubt. But what he does himself he cannot doubt." Dr. Knapp believed that a man must be led to take good care of land with his hands and mind before he will really care for his soil and his country at heart. Then, as the man sees the soil bringing forth strong new growth upon his fields, it is not only the crops that grow, Knapp said: "The man will grow faster than the crop."

Something much like this is happening to millions of farmers, gardeners, foresters, and water and wildlife technicians; and also to medical men, engineers, nutritionists, geographers, and geologists, who see this whole process of regeneration as a process inseparable from the conservation of human health and values, all over the United States. The measurable physical results, while great, will, I think, prove in the end not as permanently important as the widespread and all but immeasurable change in personal and social attitudes.

Professor Gilbert Wooding Robinson, of the University College of North Wales, has stated the case sweepingly and justly, on the whole. "Nowhere else than in the United States of America," he wrote in his book 'Mother Earth,' "Nowhere else has the drama of soil destruction been so swiftly enacted or on so great a stage." When I read this some five years ago I agreed with every word of it, and I went around my country together with other zealots declaring the same tidings to all who would give ear. I was a member of a new movement or society called Friends of the Land. Our excesses of hope as to the agricultural future of America had given way suddenly to a possibly excessive shame and despair. In 1928, when I was assigned to draft the first national bulletin on accelerated erosion and soil repair,[1] I started by saying that our farms, counties, and states were moving into each other or out to sea "at a rate for which there is no known precedent over a country as a whole."

Subsequent publications and events leave some doubt as to our claim to such distressing pre-eminence. Perhaps we North Americans are not after all the world's greatest soil-miners. Trouble is appearing on the face of other lands even more recently settled and farmed mainly by western Europeans according to the European or British tradition. South Africa has bad and increasing erosion. So have many parts of India, and the dust-storms of Australia are almost as prominent in the world's headlines as were our American dust-storms of the nineteen-thirties.

Why do such things happen when men of British or European blood and training remove their farming operations to foreign lands? The impulse or tendency to abuse good land cannot be in the blood of the Celt or Anglo-Saxon. If it were, you would be doing so here also; and in general you are not. But I think that the sea-change which seems to come upon good European farmers when they immigrate to America or Africa or Australia is not to be explained on the ground of an assumed moral superiority among those who remain here, or by attributing a special moral insensitivity to those who emigrate. The difference is far more likely to derive from a change in the weather. Climate, hardly less than soil, shapes the individual, the regional, and the national mood and bent.

[1] "To hold this soil." *Miscellaneous Publication, No. 322.* United States Department of Agriculture

Thomas Burke says this very well in his recent British Council pamphlet, 'The English and their country.' "The spirit and manner of a people," he observes, "is made by the spirit of the landscape and the nature of the soil on which they live." Taking this as his basis, Mr. Burke proceeds to analyse your northern and southern Englishmen, your marshland people and your highland people. We find much the same human variations on our different soils at home. But there is, I think, a further general difference. The extremes of the climate of America as a whole have instilled in us, perhaps, a certain recklessness and extravagant optimism. Our pioneers entering rich Arkansas on the westward march wrote back East of soils so rich and deep that men put turnip seed in the ground and ran. When the dust blows on our High Plains to-day you still hear tales of gophers 500 feet up in the air, burrowing; and instead of a wind-bag to gauge the velocity of the wind out there they use a log chain. We are not soothed, as you are; we are slightly maddened by our weather. "You see, Sir," as an English soldier serving under General Braddock wrote to his people in England many years ago, "what a wild set of creatures these Americans are when they lose society."

To speak more seriously, our soil troubles have come, really, not so much from our daring to try new forms and ways of culture as from a stubborn adherence to methods that we inherited. By clinging to practices that worked all right in the old country we were led for more than a century to develop a misfit agriculture that was ruining our land. Here in England the rains fall softly. Our rains and winds in America slash and bite. When we bare land for row-crops and expose it to the beat of the weather, as we have done under the harsh compulsions of cash crop economies, the rain dashes off with grit in its teeth and tears down our soil like a billion furious buzz-saws. That is only the beginning of the trouble. The misplaced silt chokes our creeks and rivers and harbours. The process of ruin is accelerated by the fact that the closer the rain cuts down to subsoil the faster the soil runs out. The consequences become increasingly disastrous and far-reaching. Excessive erosion deranges our natural ground-water supplies, stifles fish, starves wildlife, and stops dynamos with grit and boulders. And finally, by removing along with the soil its more soluble nutrient minerals, soil erosion leads inevitably to an eroded nutritional base and an eroded people.

So much for the gloomy side of a rapidly moving picture. We have not yet conquered soil erosion in the United States; we have barely half conquered it; but we have learned, we think, in the past ten years, how to halt or still accelerated soil run-off or blow-off; and now we are learning how to build up soil instead of diminishing or wrecking it.

Surely it is proper to speak of accelerated erosion as a destructive process. But it becomes more doubtful every year whether we should speak of even badly eroded soil as "destroyed." Our Soil Conservation Service made rather free use of this word in its first pronouncements. After only a few years' work however our erosion reconnaissance specialists began to hedge a little and to speak of such soils as "essentially destroyed." This is a curious scientific distinction. I think we had better find some other word than "destruction" when we speak of soils. I think, further, that we must seek some word more active

and hopeful than "conservation" when we speak of regenerating soil, water sources, forests, livestock, wildlife, and people.

If all the 50 million acres of eroded American soil which our reconnaissance surveys of the early nineteen-thirties reported as "destroyed" had been actually destroyed, that would have meant nearly 80,000 square miles of land, an area almost equal to all of England plus all of Scotland, permanently out of production. This has not proven so. By developing processes of soil repair, soil building, and a restitution of the essential elements, we are raising fairly good crops on some of this "destroyed" soil now, and we are learning to do a better job of soil reconstruction year by year. If in the years to come more young research students and technicians can be led to regard the eternal interaction of soil, rain, sun, and air with the same constructive imagination which is now accorded that later and minor marvel, the working of the internal combustion engine, I would not be surprised if the human race learnt to build productive soil even on bedrock, and built it rather fast.

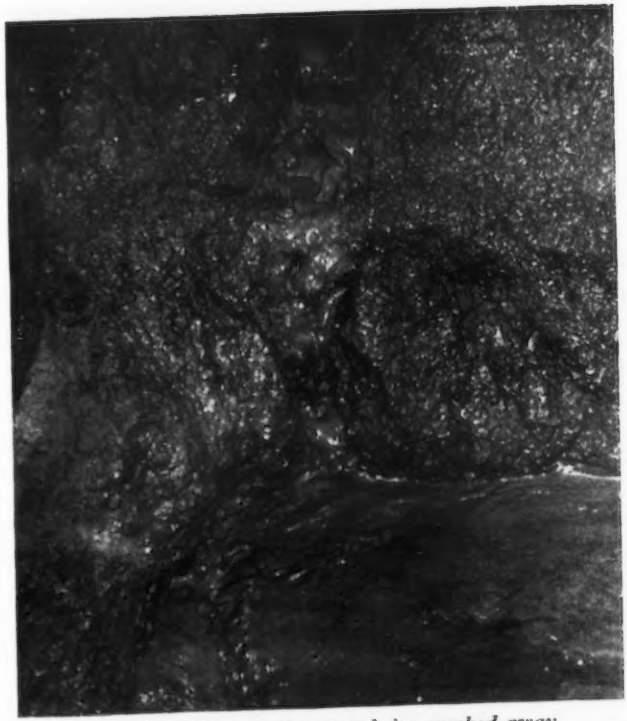
In addition to the 50 million acres initially reported destroyed or essentially destroyed, not less than another 150 million acres of the soil was reported as more or less impaired. In total, then, some 200 million acres of our entire area of 1903 million acres was found upon survey, and I think rightly, to be seriously eroded, leached, or depleted by overcropping without proper replenishment or care. To put it in still another way, about half our present cropland of 400 million acres showed plain signs of having been abused by careless or faulty culture when we started this national campaign of repair and restitution in 1934.

The yield of all this land had run down, and in varying degrees, but discernably, the quality of the yield had suffered. Not infrequently the diminished quality carried through visibly from stunted plants to scrawny livestock to sagging homes and fences and barns, and to sickly, spiritless people. The blight that had settled on such farming communities carried through moreover to the whole trading area round about them. When a soil runs down, as the saying goes, farmers are not the only sufferers. When the soil fails, everything fails.

The distress these conditions aroused was complicated and aggravated at the time by a widespread financial distress which for twelve long years had borne down hard on agriculture in particular. Some people said, and still say, that the reason our farmers had racked their soil was simply because they had to beat a living out of it at starvation prices. There is some truth in this view, no doubt, but it is too simple an explanation to account for the entire trouble. The most sweeping harm that had been done had manifestly occurred during the period of soaring prices which marked the first World War period and the continuing boom immediately afterwards. When that boom had ended our soil lay wounded, and even that soil, still hard driven, was piling up what we called "surpluses" of food and fibre—surpluses only in that needy consumers in our own and other countries did not have the money or credit to pay for them.

It was an ironic and tragic situation; and the great drive toward a sounder basic culture in our country began full force, it is strange to recall, only after the most spectacular mass sacrifice to strictly commercial *mores* in the history of mankind. Nine-tenths of the cotton farmers in our country trudged out of

Grassland, contour-furrowed to control run-off



Rich bean land on the coast being washed away

Gully caused by drip from barn, Stewart Co., Georgia

to their holdings in the spring of 1933 and ploughed down one-fourth of a standing crop. This was not designed as a conservation measure: it was a Government-organized effort to create a relative scarcity.

That seemed to do the business, for the moment. It raised the price of cotton. The raised price, together with a mild inflation and a measured outpouring of governmental adjustment payments, brought our Southerners back into the market as paying customers of our factories, merchants, railroads, and banks. There can be no doubt that this strictly commercial manoeuvre did a great deal to help to enliven a business recovery. But it was a repulsive performance none the less. Some men wept as they ploughed all that good cotton back into the ground unused. They may not have been very good farmers at the time. There can be no such thing as good farming under the rough compulsions of a strictly one-crop economy. Yet in showing their shame for the mess that monoculture had got them and their country into, these farmers were moved by the right and decent instinct. They wanted to farm better and to make the earth richer. They wanted to produce and to provide, feed the hungry, and to clothe needy people. Above all, and under their whole distorted striving, these farmers wanted to take better care of their land. Strange to tell, the conservation ethic, as we have come to call it in the States, took root and strengthened among Southern farmers most firmly and rapidly after that great sacrificial plough-in of cotton. Travelling over the great Mississipi Delta during the summer following I saw something that I had never seen there in years past. I saw great fields of grass, alfalfa, lespedeza, and clover, among the vast brown stretches of cotton. Where cotton had been ploughed under the land looked bare and idle in growing weather and the farmers did not like the look of that. They spent their own money, they still had very little, for grass seed to cover these bare spaces. In so doing they made their first step away from the domination of King Cotton, and began to approach a balanced and permanent programme of mixed farming.

In like manner, as they felt their way along, Henry Wallace and the other leaders of our governmental drive to adjust crop acreages to the needs of a changed world, removed emphasis from a reduced production to a more balanced production, together with a protection and enrichment of the source. Our Agricultural Adjustment Administration became more and more a working adjunct of our Soil Conservation Service, our Forest Service, and our Tennessee Valley experiment in regional rehabilitation. Later it was all geared to accord with the Ever-Normal Granary, Lend-Lease, and the Food Stamp Plan.

Gradually grass and trees and good livestock have been introduced and induced to thrive where cotton, or wheat, or Indian corn alone had exerted a baleful rule. It was really an amazing exhibition of the flexibility of democratic procedures in the light of an aroused public understanding and conscience. To-day our Government is rewarding the keepers of land not for growing less, but for growing more, and growing it safely under the protection of contoured fields, with proper rotations, proper fertilizing, and proper care.

Last spring when I was working as a writer for the Tennessee Valley Authority, I wrote something about the all but miraculous results of new

farming methods on the foothill farms of the Great Smokies. I took the article for check-up to the wisest and most seasoned of T.V.A. field men at the University of Georgia, where I also had my base. S. G. Chandler changed only one word of what I had written. He told me not to use the word "new" in speaking of modern conservation methods designed to rebuild fertility and control the destructive flow of water on the land. "It isn't what we didn't know," Chandler told me. "It was what we had forgotten."

That is true. When you come to examine the essentials, we have invented nothing new in detail in our entire New Deal agricultural programme. We have simply gone back to neglected or forgotten wisdom and applied it in a new working pattern or combination that suits our land and climate. Our first president, George Washington, warned us against the one-crop system. "The cultivation of tobacco," he wrote in 1787, "has been almost the sole object with men of landed property, and consequently a regular course of crops has never been in view." A somewhat testy squire, Washington railed at overseers "who could fill all the land with Indian corn," and ordered this clean-tilled row-crop off the fields of his place, Mt. Vernon. "Very few persons have attended to sowing grasses, and connecting cattle with their crops," he wrote to his friend Arthur Young, the English agriculturist; and added: "A half, a third, or even a fourth of what we mangle, well wrought and properly dressed, would produce more than the whole under our system of management; yet such is the force of habit that we cannot depart from it." Toward the end of his life Washington came to lay great stress on the virtues of a rough surface with mingled "vegetable rubbish" to help hold topsoil. American farmers as a whole are now coming round to that idea as if it were a recent discovery.

From his farm, Monticello, in the Piedmont upland, Thomas Jefferson announced similar discoveries at the dawn of the nineteenth century; and he was the first recorded advocate of what we call contour terracing, contour cultivation, and contour strip-cropping, the very base of our whole working redesign for American farm layouts to-day. In 1813 Jefferson wrote as follows: "We now plow horizontally, following the curvature of the hills and hollows on dead level, however crooked the rows may be. . . . At present we lose none of our soil, the rain not absorbed at the moment of its fall being retained in the hollow between the beds until it can be absorbed. . . . In point of beauty nothing can exceed that of the waving lines and rows winding along the face of our hills and valleys. . . ."

This, indeed, is the right, the safe and the beautiful way to dress a rolling countryside in a land of violent climate. The landscape stays in place, and water in itself is so large a part of any crop that fields so tilled throughout our country often yield one-fifth to one-third more even the first year after they are cut to the contour instead of to the up-and-downhill, square pattern of the past. But it has taken the farmers of America more than a hundred years to come round to the idea and make level land out of hill land, as Jefferson proposed.

I could go on and tell you more about many another anciently respected practice which has been brought into action again and correlated with other practices to preserve and revive our soil; but this is not an audience of farmers.

Gullies in recently settled land, Oregon

Strip-cropping, Lancaster Co., Pennsylvania

Wind-eroded field in South Dakota

The same field contour-furrowed and sown with cane and Sudan grass

Let me simply indicate how one revival of a sound practice has led us on to another, and continues to do so still with enlivening effects. First it was terracing, a most ancient practice. We had machinery which the ancient Peruvians did not have, so we surged out at the very beginning of our soil drive to protect America from washout by throwing up machine-made terrace earthworks along the contours on millions of acres on end. I think that in our zest we rather overdid the thing, in that first great spurt of terracing.

Now as I go around our country I often see terraces that have been worked over and abandoned. It is safe now; grass has taken over. Our major farm march in recent years has been markedly toward new grassland, leguminous ley particularly, bright new grassland making a solid sward of cover. We have even begun to fertilize grass. That, to us, is as startling a break with precedent as your forced march away from meadows toward arable culture here. After the war I hope there will be a resumption of all the promising experiments in grass-drying which were under way in both our countries when war came. Many in my country have come to believe in the prophecies of an Illinois engineer named Arthur Mason, who found thirty years ago that much of even the seemingly level land of our Corn Belt had lost half its topsoil by rainwash. "A nation with muddy streams is inevitably impermanent," he said. "A nation with clear streams alone is permanent." And Arthur Mason predicted that we shall find a way to get away from clean-row maize culture entirely, to stitch down the soil of our Corn Belt with thick grass stands, and to feed this grass to livestock and even to people dehydrated, as a full nutrient substitute for grain.

New farming implements are coming into use to expedite and speed our reformed farm practices. So are new social instruments. Farmer citizens' committees, working by districts, run most of our conservation field work now. Also we are developing for the first time a lively and literate set of agricultural debaters and writers with a general following. The turning plough, as you may have heard, is under attack. Edward Faulkner's lively and contentious book, 'Ploughman's folly,' is now in its five hundredth thousand. That, I dare say, comes close to the largest sale of any book on technical farming since the time of Virgil. All this is healthy; it betokens a new sensitivity and respect which surely is due to the soil. The differences between those who breathe incantations to humus, and those who swear by artificials alone are, I think, likewise healthy, especially if the contenders jostle their way to some reasonable middle ground and combine their working knowledge.

The American conservation movement has added at least a new and needed leaven to general education. It has tended to make us apprehend more clearly the relationships of soil, rain, sun, man, and the works of man. I have sometimes wondered at the blindness of working American farmers or agriculturalists, who let our soil run down under our very feet, and saw attendant symbols of decadence arising at every hand, without ever seeming to realize what was happening. I have wondered how old a man has to be, or how far he has to travel before he can look at a living landscape and see what is going on. For my part, I did not begin to see landscapes, rural and urban, and seascapes, and cloudscapes, as parts of a unified, organic, living structure until I was thirty; and not until I was forty did I see the American scene in its

entirety—forests, farms, wildlife, gardens, mines, streams, factories, live-stock, cities, and people—as a living structure going dead on us, running down.

Americans have definitely made the turn for the better now. But we have still a long way to go. Hugh H. Bennett, Chief of our Soil Conservation Service, testifying before a congressional committee early this spring, said that at the present rate of work and progress it will take another fifty years to bring all of our farmland and rangeland into such revised farming plans and layouts as will make certain its permanent usefulness.

Fifty years is too long. I do not believe that it will take us as long as that. Once this war has ended, once all of the skills and machines and ardour which now we must throw into the business of destruction can be turned to works of peace and permanence, we shall do better. No, I do not think it will take us another fifty years, or even twenty, to put all of our land into better order. By the time we have done this, we shall have another generation in power; and I believe the young will have learned enough by that time to use the land more reverently, more permanently, and more productively than their fathers ever dreamed of when they were young.

DISCUSSION

Before the paper the CHAIRMAN (Field-Marshal Sir PHILIP CHETWODE, Vice-President) said: Unfortunately, our President, Sir George Clerk, is unable to be present this afternoon, and he has asked me, as past President, to preside. I feel it an honour and pleasure to introduce to you a most distinguished American visitor. Mr. Russell Lord is an authority on rural life in the United States, and he has done much to further an understanding of the right methods of combatting erosion and of conserving the soil. Soil erosion on a large scale is not a serious problem in Great Britain, but in the United States and in the Dominions, as experience in what is known as the Dust Bowl in particular has shown, its control is vital to the life of the countryside. This problem is only part of a much wider one: the place of a well-balanced agricultural community in national life. Mr. Lord, through his organization, "The Friends of the Land," has brought scientists, farmers, industrialists, and the general public to recognize their common interest in the prosperity of the countryside. He himself has described the paper he is to give to us as a summary of "the changes we have made in the American landscape in order to hold it more nearly in its proper place and make it more fruitful."

Mr. Russell Lord then delivered the lecture printed above, and a discussion followed.

The CHAIRMAN: We have with us one or two experts on the subject of soil conservation. Perhaps Mr. Jacks would add a word on the subject.

Mr. G. V. JACKS (Director, Imperial Bureau of Soil Science, Rothamsted): We are all very gratified to have had Mr. Russell Lord to address us to-day. He is well known in this country as a propagandist of soil conservation and his vivid writings are widely read. I have listened to his remarks with great interest.

There are one or two points on which I should like a little further information. I have always felt that soil conservation is a process of social evolution in which it is possible to distinguish definite phases. A feature of the American work on the subject is that the Americans have reached a more advanced phase than any other country in the world. The first phase in soil conservation is when it is realized that water on a slope will run downhill and that something has to be put

Dust-storm, Texas

Land worked on the contour, Pecan Creek, Oklahoma

Basin listing: ridges built at intervals across contoured furrows to hold the rain

Strip-cropping on the contour, Iowa

the way to stop it. That phase is characterized by the building of terraces and e adoption of contour farming, damming gullies, and such things. There is thing wonderful about that; everybody has known how to stop water running wnhill ever since the world started.

The second phase is when it is realized that if the soil is fertile the water that ls on it is absorbed into the soil and will not run downhill at all. Hence the portance of building up the fertility of the soil. Again, there is nothing nderful about that. As Mr. Russell Lord has said, after the agricultural pression a good deal of land in the United States almost automatically went ck to either natural or sown grass, and it was found that the grass cover pre-nted soil erosion not only by acting as an obstacle to the run-off, but also by aking the soil more fertile and opening it up so that the water got into it. When is second phase where the fertility of the soil is built up is reached, either by e selection of suitable soil-conserving crops or by the adoption of fertility-romoting agricultural systems, one knows pretty well all that is necessary for il conservation.

But regions where soil conservation is efficiently practised are very limited. he United States is about the only country which has tackled the problem of il erosion on a national scale. It has reached a third and more advanced phase f soil conservation in which the occupiers of the land work together to adjust emselves to the problems of the land as complete communities. It is that hase on which I should like a little more information from Mr. Russell ord.

It is only within the last six or seven years that the United States has realized e importance of cooperation between farmers and rural communities in con-ection with soil erosion, and I should like to hear something more from Mr. ussell Lord as to the cooperative movements for soil conservation, and par-icularly the soil-conservation districts. It seems that some similar development ill occur in other parts of the world. The soil-conservation districts, if we can elieve all the records we have over here, have had an extraordinary effect on e whole prospects of soil conservation.

I should like also to ask if science has contributed anything original to soil nservation. All the dodges of soil conservation are straightforward measures r stopping water running down a hill. I do not think any of the modern ter-ces are products of the scientific mind; such things as contour cultivation, rip cropping, and the various other soil-conservation measures are, I believe, ll ideas evolved by simple every-day farmers who found out how to do what as necessary. Science came in later and explained why the measures adopted orked. I do not know that there is anything that science itself has contributed soil conservation.

Mr. RUSSELL LORD: In replying, I will leave science out of the picture for the oment. The conservation districts are extremely important. We had our ederal Act at the end of 1937, and it provided that the States would have to ass their own Enabling Acts. It is extraordinary to realize the demand and the pidity with which the States passed these Acts. There are one thousand two undred soil districts operating in the United States, and it is remarkable that he farmers themselves run these districts, the scientists being subordinated in n advisory council. I live in an area in which there is a very active soil district, ne of the first in my State of Maryland, and before I got into a plane to come o England a lawyer, a farmer, and a school teacher came to discuss with me the ubject of soil conservation. As a result I prepared a pamphlet for circulation. We intend to get our whole county under contour in ten years. The farmers ave taken up the suggestion in a marvellous way. When the war is over and the

civil servants come home it is hoped that the farmers will still run the show and scientists will advise.

Dr. DUDLEY STAMP: It gives me great pleasure to speak this afternoon if only for a personal reason. I spent a year, in 1933–34, in the United States studying this question of land utilization and soil erosion. The help and hospitality I received on that occasion constitute a debt which I certainly shall never be able to repay. I should like to feel that we are able to make Mr. Russell Lord welcome in England in anything like the way in which one was welcomed in the United States. It was a most interesting time because, as you will have gathered from Mr. Russell Lord's address, things were getting going. The Roosevelt administration, under the New Deal, was setting up State Planning Officers, and in every State attention was being turned towards soil erosion problems. It was my task to visit forty-seven out of the forty-eight States on this question of soil erosion. I did not visit the forty-eighth because it was so dry that year that they told me the soil was nearly all blown away, and they did not want me there. Mr. Russell Lord will remember the summer of 1934 in North Dakota.

Of the points which particularly impressed me during the lecture there is one on which I would like to quarrel mildly with Mr. Lord: the suggestion that so many of these soil troubles are due to the taking to the United States of the European or, more strictly, the Anglo-Saxon methods of farming. I wonder if that is right. The early Anglo-Saxon settlers who went to New England began to carve out for themselves small fields arranged around village sites in much the same style as we have in England. They were unfortunate because much of the land which they tried to clear was intrinsically very poor, and to-day one has the tragedy of land, laboriously cleared of forests, which has been abandoned and is once more overgrown by scrub and woodland. But those Anglo-Saxon settlers did try to carry out the English Anglo-Saxon tradition of the rotation of crops on the farm.

I venture to suggest that the new trouble came with the discovery of the vast prairies of the Middle West, a new geographical environment which the settlers did not understand, and it was the exuberance of emancipation from the slavery of poor land which led to the trouble, the carving out—this is not Anglo-Saxon—of huge square blocks 160 or 320 acres to the farm and the indiscriminate ploughing, in defiance of the natural drainage lines, straight across those square blocks. As a result, Nature asserted itself.

I remember addressing a large gathering of Illinois farmers in 1934 and saying that if I were able to come back and look at Illinois again in twenty years' time I should not know it from our own county of Norfolk in East Anglia. Big fields would still be there, but instead of being regular they would be irregular in shape. The irregular shape of our fields has been rather despised by past generations of Americans, but the sizes and shapes have been dictated by natural drainage. This is precisely what is now happening in the United States so that irregular shapes will replace the unnatural and dangerous rectangles.

Having got my little quarrel off, I should like to add that I feel the address to which we have listened is particularly appropriate to a geographical audience. After all, geographers are interested in all parts of the world, and the geographical approach, that is, the comparative approach, is surely most valuable.

Mr. Jacks is quite right. The devices against soil erosion are not new. They are to be found in practice in many parts of the world, and we have much to learn even from the practices of what we call primitive races, to help us with our modern problems. The picture of "basin listing" in America might well be of basin cultivation as carried out in the wettest parts of Nigeria. Some of the pictures of the American terraces might very well be on the hillsides of South-

Western Arabia. If we study intensively these pictures in various parts of the world we may get valuable hints for solving our modern problems.

I think also the historical approach to the study, which Mr. Russell Lord mentioned, is very interesting. Again and again at the present day I read passages from Arthur Young and his contemporaries of one hundred and fifty years ago which tell us precisely what we ought to be doing in Britain at present. Much the same applies to Thomas Jefferson, who was one hundred and fifty years before his time. He had so many gadgets in his house at Monticello. His folding bedside table with an adjustable lamp, and the "television" which he perfected with the help of a telescope to see whether his men were at work 2 miles away are devices which we are just beginning to make use of now.

Finally, I am glad in another way that Mr. Russell Lord has spoken to us this afternoon. Amidst all the progress we have made in Britain during this war we have not yet learned that the dangers of soil erosion are quite near to us—dangers resulting from increased cultivation. I think it is no secret now that during the last four years we have seen soil erosion here on a scale which ten years ago we should not have believed possible. I have been in a dust storm not 140 miles from this building. I have seen the removal of old wind-breaks and, as a farmer put it to me when he had been suffering wind erosion: "I sat the other side of where that old wind-break had been and caught the brussels sprouts as they were blown out of the ground." Some of my colleagues who are economists are envisaging that the type of agriculture in this country after the war will be monoculture or prairie agriculture. Mr. Russell Lord has shown very conclusively that monoculture is a thing of the past which is disappearing from the United States and that the prairie type of farming is not the right kind of cultivation for any land. I hope that the economists who think along these lines for the future of our country will learn that lesson from the United States. Thank you very much, Mr. Chairman, for allowing me to speak and to express my thanks to Mr. Lord.

The CHAIRMAN: It is now time to close the discussion, and to perform my duty of asking you to pass a most sincere vote of thanks to our lecturer for what he has told us this afternoon. We British and Americans have come to know each other very much better during these war years. We have two characteristics in common: one is that we loathe war; the other—and this always seems odd to me as an old soldier—is that we flatly refuse to get ready for it beforehand. We have come through, and we have come to know each other very well, and certainly better. Such lectures as we have heard this afternoon help us both. The more we know about what happens in the United States, the difficulties they have to face and overcome, the better. The friendship between our two nations has to be maintained, because the happiness and the future of the world depend upon it. I now have very much pleasure in asking you to record most hearty thanks to Mr. Russell Lord for his exceedingly interesting address.

THE STABILITY OF NATURAL SLOPES

WILLIAM H. WARD

Meeting of the Society, 29 January 1945

DURING recent years research into the stability of foundations and earthworks has been carried out at the Building Research Station of the Department of Scientific and Industrial Research. This work has covered a wide field in civil engineering construction and has also been applied to problems of a larger geographical–geological scale, such as landslips, coast erosion, and river bank erosion. The object of this paper is to present, in the light of this recent research, a general picture of the factors which control the movements of natural slopes, with particular reference to those examples which have been studied by the Building Research Station.

In terms of geological time it may be said that no slope is perfectly stable. The problem is largely a question of degree of stability; slow movements may continue almost unnoticed in a lifetime, but over a long period they accumulate and mould the topography; more sudden movements, recurring at intervals, may be catastrophic and seriously disturb man and his works. It is largely these latter movements that the civil engineer has studied.

The subject appears to have developed along two paths, one followed by the geologist and geographer, and the other exploited by the engineer; both have strayed a little and the ground between has never been completely cleared. The former has traversed most of the earth and described the scenery and site conditions, but has recorded few detailed measurements. The latter has cut his own path, disturbed nature, and kept slopes to a maximum to save his labours, but deep in his cuttings has tended to forget the scenery and site conditions. Frequently he has had to return to deal with landslips, and maintenance has been costly, but through these experiences he has accumulated detailed measurements of his failures and has recently evolved a rational method of design. The geologist and geographer would benefit from a knowledge of the engineering methods and could assist by taking measurements on a large scale. They would then begin to understand more clearly some of the most important processes in the history of the earth's crust. The engineer could equally profit from a fuller appreciation of the long-term view of the geologist and consider the site conditions and changing climate in relation to his works.

Whereas the geologist and geographer accept landslips without any sense of responsibility as a natural process, the engineer is aware that he may have created instability and because of this responsibility he has been obliged to develop methods of estimating slope stability. With the introduction of the railways, and their restricted gradients, the engineer started to make widespread large cuttings and embankments, and the history of railway construction abounds with records of slope failures. The earlier canals with their numerous locks and contour planning had generally avoided deep cuttings or embankments. All this construction produced very little advance towards a rational method of estimating the stability of slopes. It was not until the early

part of this century that any real quantitative study was made and it arose largely as a result of the construction of the Panama and Kiel canals,[1] and the Swedish Railways.[2] These three enterprises were marred by a series of large landslips, and in the Gaillard Cut, Panama, an additional excavation of 50,000,000 cubic yards was required to stabilize the slopes. It seems probable that the delay in development of methods of estimating slope stability was due chiefly to the lack of a method of measuring the existing shear strength of the strata. Unfortunately, in this connection the work of Collin[3] appears to have been almost entirely overlooked by engineers.

Origin and causes of the failure of slopes

Where does the failure of slopes enter into the slow complex cycle of the changing face of the earth? The instability results from a number of processes, some of which are internal and some external.

Movement occurs under the action of gravity, hence the prime requirement is a difference in elevation. This arises initially from *Mountain building movements* or *Regional uplift*. These movements are of internal origin, occur slowly, and as they progress denudation takes place from external sources and develops a dissected topography with many steep slopes. These steep slopes are generally produced by a process which may be called *Undercutting*, and this is the largest single cause of steepening. Undercutting presupposes the existence of at least a slight channel of flow or a front of attack, and it tends to follow the weaker materials. Undercutting, which consists of erosion at the toe of slopes, may be caused by glaciers producing steep-sided valleys; rivers eroding at the toe of their banks; the sea attacking the foot of the cliffs; and the wind by sand blast at the base of bluffs and escarpments. Excavation and filling by man can also be regarded as a form of undercutting.

Denudation in one area leads to *Deposition* elsewhere, another external process. But although deposition generally tends to produce a fairly level surface it locally forms quite steep inclines: moraine slopes by glaciers; banks, levees, and foreset slopes of deltas by rivers; beaches by the sea; leeward slopes of sand dunes by the wind; and slopes by volcanoes. All these processes therefore can lead to the formation of steeper slopes.

We may now enquire in a little more detail as to the everyday causes of instability. Clearly a young topography will be most liable to instability and the actual cause of failure will depend largely on the type of strata. With friable materials like sand, any undercutting induces an immediate movement of the upper part of the slope, but with clayey materials which deteriorate slowly, undercutting does not necessarily cause immediate instability. The glacial undercutting of a shale or rock slope leaves an unstable face and the retreating ice is peppered with stones as a result of atmospheric weathering.

The atmospheric weathering processes, which include the various actions

[1] "Report of the Committee on the Panama Canal slides." *Mem. Nat. Acad. Sci. Wash.* 18 (1924); Fülscher, "Der Bau des Kaiser-Wilhelm Kanales." *Z. f. Bauwesen*, 1896–7.

[2] Statens Järnvagärs Geotechniska Kommission, 1914–22. Slutbetänkande, Stockholm, 31 May 1922.

[3] Collin, A., 'Recherches expérimentales sur les glissements spontanés des terrains argileux,' Paris, 1846.

of rain, wind, and temperature vary considerably in their effect and the severity of the climate is most important. The surface frosting of steep rock exposures and the rain wash of bare friable materials are fairly obvious and visible actions, but the progressive softening of stiff-fissured clays and shales is a slower, concealed, process. This latter process which penetrates the strata gradually from the surface restricts the extent of failure movement to the weathered zone.

Earthquakes and artificial vibrations have been known to cause slope failures. These vibrations impose an additional force on the slope mass. It is apparent that where large masses of material are involved the slope must be near instability for such vibrations to cause failure. An example has recently come to my notice where an ammunition ship stranded on the beach blew up within 100 yards of a coastal landslip causing no apparent movement. The slip could have had only a small degree of stability, as it had only recently been stabilized by deep rubble drains. The explosion broke windows in a town 6 miles distant. On a large scale Pascoe[1] refers to a shallow landslip in India about 20 miles long which was caused by an earthquake.

The ultimate failure movement usually involves a shearing of the material under the action of gravity, hence it is necessary to study and measure the shear strength characteristics of geological materials.

Summarizing, the failure of slopes represents that part of the process of denudation in which the solid materials predominate, in contrast to the fluid part, where air or water predominates over the solids, for example, silt transport by rivers. The failure may be caused either by erosional undercutting and/or by atmospheric weathering. When the failure will occur depends on the susceptibility of the material to erosion or weathering, and on the climate.

Types of failure

A classification of the types of failure is necessary to the engineer to enable him to distinguish and recognize the different phenomena for purposes of design and also to enable him to take the appropriate remedial or safety measures where necessary. The geographer and geologist need a classification so that they may interpret the past and predict the present trends of topography as revealed by their observations.

Ever since the stability of slopes has been studied, probably about the middle of last century, certain types of failure have been recognized, but there has been some confusion among different writers. This has been due chiefly to an incomplete knowledge of the properties of saturated materials under stress and also because in one particular landslip more than one type of failure mechanism may be involved. In addition, the introduction of careful subsurface exploration is comparatively recent. The chapter on landslips in 'Ingenieurgeologie,' written by K. Terzaghi,[2] was probably the first comprehensive treatment of the subject based on the quantitative study of the materials. This book is unfortunately not easily obtainable in this country.

Broadly the type of failure is dependent on two factors: the geological strata and structure of the slope, and the climate, that is, intensity and frequency of

[1] Pascoe, E. H., "Indian earthquakes." *J. R. Soc. Arts*, 82, No. 4247, April 1934.
[2] Redlich, K. A., Terzaghi, K., and Kampe, R., 'Ingenieurgeologie.' Vienna, 1929.

rain, temperature changes, and wind. In addition to this broad classification it is necessary to recognize several distinct types of failure. These are given in Table I (p. 174) chiefly in order of depth of movement, as compared with the length or height of the slope. The table, to some extent, divides itself up into fragmental and cohesive materials, the former usually being associated with surface movements and the latter with deeper movements. The surface movements are of an erosional nature and tend to involve particle movement, while the deeper movements involve mass movement. Throughout the earth's surface mass movements are probably as important as surface movements in moulding the topography.

The various types of failure will now be described in more detail. The examples quoted are taken as far as possible from the records of the Building Research Station and refer to this country only. The work often involves the cooperation of other authorities, and wherever possible due acknowledgements are given.

Solifluction.—Solifluction movements may be classed as a modified form of soil creep with the freezing and thawing process predominating, and may only affect the top few inches of soil. In capillary saturated silts and fine sands (or more widely graded materials of similar permeability) a slowly descending frost line draws up additional water from the unfrozen soil to form lenses of ice. The surface heaves by an amount closely equal to the aggregate thickness of these ice lenses. This is known as "frost heaving" and it concentrates larger quantities of water within the soil than is possible by any other known process. This water is rapidly released on thawing. Drainage through the soil may be sufficiently restricted for the melt water to carry temporarily the weight of the overlying soil, which behaves as if it is floating, and consequently shoots down the slope. With freer drainage or slower thawing the soil becomes mud-like and flows more slowly down the slope, often in a lobate form. The same frost-heaving process may cause a sorting of the various sizes of particle and produce interesting patterns, such as stone stripes or terraces, as the soil creeps downhill.[1]

These solifluction processes are quite noticeable in the mountainous parts of this country, but they are of minor economic importance. On the Alaska Highway however they proved very troublesome, when the stripping of large thicknesses of decayed vegetation resulted in the thawing of perennially frozen ground, causing slope failures as well as road foundation failures.[2]

That these three minor surface movements of soil erosion, soil creep, and solifluction were more common when our climate was more severe is shown by the recent detailed mapping by members of the Geological Survey. They propose[3] grouping together the local drift formed by these various processes under the general term *Head*, and on the new geological maps it is

[1] Taber, S., "Perennially frozen ground in Alaska." *Bull. Geol. Soc. Amer.* (1943) 1433; Beskow, G., "Tjälbildningen och Tjällyftningen" (with English summary). *Sverig. Geol. Unders.*, Ser. C. No. 375, 1935.

[2] Taber, S., "Some problems of road construction and maintenance in Alaska." *Public Roads, Wash.* 23 (1943) 247.

[3] Dines, Hollingworth, Edwards, Buchan, and Welch, "The mapping of Head deposits." *Geol. Mag.* 77 (1940) 198.

Type of failure	*Movement*	*Climatic and other factors*
Surface erosion, creep.	Solifluction (frost heaving and thawing).	Temperature, rain.
	Soil erosion, involving rapid transport of surface materials by wind and rain.	Wind and rain.
	Soil creep.	All.
Fragmental slides (1) Dry.	Rolling down of surface layers of scree, sand, and gravel slopes.	Wind, vibrations, earth tremors.
(2) Partially saturated.	Fine material behaves as if slightly cohesive, shallow mass slide. Shale screes develop cohesion and become detritus slides.	Rain, wind.
(3) Saturated.	Saturated fine loose sands may pack closer on slight disturbance, and behave as a heavy liquid. Submerged dense sands behave as in (1).	Rain, vibrations, earth tremors.
(4) Seepage instability.	Collapse of overlying strata undermined by washing out of sand.	Rain, tides.
Rockfalls and slides.	Falls resulting from frost action and deeper slides along joints and faults.	Temperature, rain.
Detritus slides.	Shallow mass slides in predominantly cohesive materials, considerable relative distortion within the moving mass, mud runs.	Rain.
Rotational shear slips.	Deeper seated rotational slips, minor initial distortion of moving mass; typical of clays.	Rain.

TABLE I

being distinguished from glacial and river drifts. I have encountered such deposits in the course of site investigation for engineering works.

Soil erosion.—Soil erosion is fortunately not, as yet, a serious problem in this country. Unlike most of the other types of failure it is not essentially a gravity movement. It involves the surface transport and pick up of friable soils under the frictional drag of water and wind. Water is the predominating agent, and erosion occurs in the absence of a surface binding. Water erosion is most liable to occur when the water is concentrated, *e.g.* by ploughing up and down the slope, and here the steepness of the slope is clearly important. Several examples of water erosion leading to gulleying have been recorded recently.[1] With wind erosion the slope is not a contributory factor and most of the wind erosion in this country occurs in unbroken flat land in Norfolk and Suffolk. Here some of the worst erosion has occurred during winds not exceeding 35 miles per hour after a dry spring.[2] Both these types of erosion occur only where there is a lack of adequate plant growth, and preventive measures aim at maintaining plant growth. By strip cropping it is possible to reduce the exposure of bare soil to a minimum; while one strip is being ploughed the adjacent crop acts as a wind break and tends to trap blown soil. In the case of water erosion contour ploughing, lister seeding, and terracing, all aim at breaking up the slope and the free run of surface water.

Soil creep.—This phenomenon is one of slow progressive downhill movement of the upper few feet of soil. It is the result of an accumulation of minor seasonal processes, frost action, thermal expansion and contraction, shrinkage and swelling which under the action of gravity lead to an inevitable downhill migration. To some extent the type of movement is modified according to the dominant seasonal process. It is naturally of widespread occurrence particularly in stiff-fissured clays and on a slope of only 10 degrees in humid climates the movement may amount to $\frac{1}{4}$ inch per year.[3] The ridging of sloping fields in the London clay region is due largely to soil creep and the cracking of houses and deformation of small retaining walls may be traced to this action. Slopes of granular materials such as scree slopes may creep downhill due to thermal expansion and contraction alone.[4]

Fragmental slides.—The term "fragmental" here refers to cohesionless materials such as sand, gravel, and scree. The failure of slopes composed of these materials most commonly involves a shearing or rolling movement of the surface fragments only, parallel to the slope. In classifying the failure of these materials it is necessary to consider several common conditions which involve the state of saturation and seepage of water through the deposit. These

[1] Morris, F. G., "Severe erosion near Blaydon, County Durham." *Geogr. J.* 100 (1942) 257.

[2] Brade-Birks, S. G., 'Good soil,' Ch. XI. London, 1944.

[3] Terzaghi, K., "The mechanism of shear failure in clay slopes and the creep of retaining walls." *Public Roads, Wash.* 10 (1929) 177.

[4] Davison, C., "Note on the movement of scree material." *Quart. J. Geol. Soc. Lond.* 44 (1888) 232–38.

conditions will be considered under the headings: Dry; Partially saturated; Saturated; and Seepage instability.

Dry: The stability of dry slopes is independent of the height of the slope and is only a function of the density of packing of the material. Due to small surface weathering effects, the surface grains are invariably loosely packed and the slope rolls down to what is known as the angle of repose. It is emphasized that only in relation to these materials should the term "angle of repose" be used, since in all materials which exhibit cohesion the stable slope is a function of the height of the slope. It has been found that the angle of repose corresponds to the angle of internal friction (ϕ) of the material at loose packing. The range 30°–35° covers most natural materials. The toe of a fragmental slope in nature tapers away in a concave slope to the base level (Wood calls this the waning slope).[1] This may be formed through the kinetic energy gained by the fragments in travelling down the angle of repose slope (Wood's constant slope) or by surface erosion caused by rain wash in the finer materials.

Partially saturated: In damp materials which are sufficiently fine to develop capillary forces, or with slightly cemented grains, the material behaves as if it is cohesive and the failure movement is more deeply seated. The slope is stable at angles much steeper than the angle of repose when dry and depends on the degree of saturation or cementation. The height of the slope also becomes critical. With surface drying or weathering the surface grains may lose their apparent cohesion and roll down to build up a talus at the angle of repose.

Saturated: On a completely submerged slope through which there is no seepage of water the conditions of stability are identical with the dry condition provided the material is not very fine and loose. That is to say, the height is not critical and the angle of repose is identical with that for the dry material.

In the case of deposits of saturated loosely packed fine sand occurring either throughout the slope or underlying other strata, the grains are liable, on slight disturbance, to become more closely packed. When such a sand compacts, the deposit becomes momentarily over-saturated and its weight is carried by the pore water, consequently it behaves like a heavy liquid and suddenly flows horizontally taking any superimposed strata with it. This condition is most likely to arise for instance when the drainage of the excess pore water from the sand is impeded by a long flow path and by low permeability such as with a very fine sand containing quite a small percentage of clay. Several examples of this type of failure are on record and they have also occurred in artificial fills of loose sand where subsequent flooding has produced sufficient disturbance.[2]

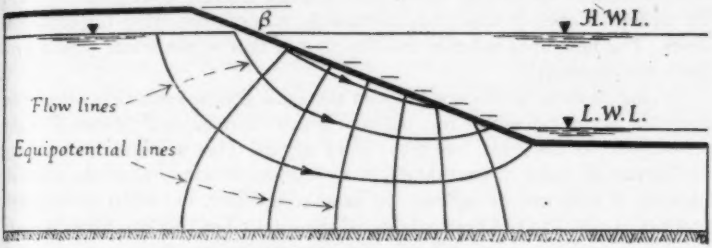
If saturated loose sands are encountered they should be regarded as inherently unstable. Failures may be avoided by carefully draining the sand either by temporarily lowering the ground water and then compacting it and allowing it to re-saturate, or by permanent drainage and compaction. The normal quicksand phenomenon encountered on fine loose sand beaches is due

[1] Wood, A., "The development of hillside slopes." *Proc. Geol. Assocn. Lond.* 53 (1942) 128.

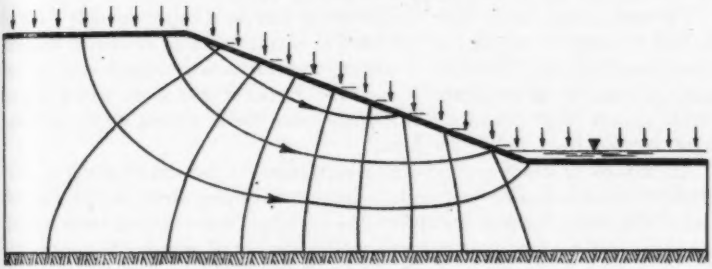
[2] Justin, J. D., "The design of earth-dams." *Trans. Amer. Soc. Civ. Engrs.* 87 (1924) 44.

to the same supersaturated state. A man walking on the saturated beach produces sufficient disturbance to cause compaction with momentary liquefaction.

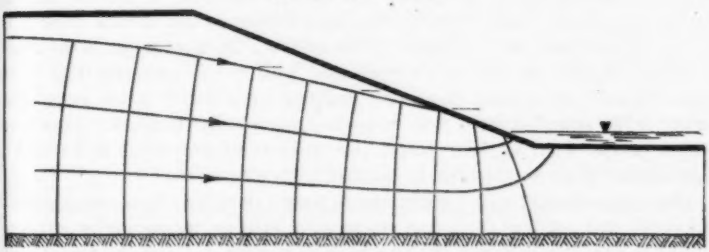
Seepage instability: The seepage of water from a slope clearly causes instability and grains of fragmental material may be completely washed out



(*a*) *Rapid drawdown*



(*b*) *Heavy rainfall*



(*c*) *Steady ground water seepage*

Fig. 1. Typical seepage flow nets

towards the base of the slope. Similar conditions may arise in a thin bed of sand outcropping on a slope, where washing out of the sand by seepage may result in undermining all the superincumbent strata.

There are three common seepage conditions which arise in nature on sand slopes and the stability of each is considered. They are: (*a*) Adjacent to tidal water when the tide falls rapidly in comparison with the permeability of the

sand, this is often referred to as the "rapid drawdown" case (wave action is neglected); (*b*) when a sand slope is completely and continuously saturated by heavy rainfall; and (*c*) steady ground water seepage from within the slope.

The first two conditions produce the most unstable state and lead to the same type of flow pattern and consequently to the same stable slope. Typical flow patterns for each of the above three seepage conditions are given in Fig. 1 for uniform slopes in uniformly permeable material overlying impermeable strata. The flow lines indicate the direction of flow of the water which produces the instability.

As long as there is contact between the sand grains, condition (*a*) occurs when the rate of fall of tide is equal to or greater than K sin β (where K is the permeability of the sand, and β the slope angle). This will arise in fine and medium sands under normal tidal fall. Condition (*b*) occurs when the rainfall intensity is sufficient to saturate the sand completely, *i.e.* when the rainfall intensity is equal to the permeability of the sand,[1] but this condition is only satisfied in rather exceptional cases in humid climates during severe rainstorms on very fine sands (K approximately 3 inches per hour).

The stable slope under both conditions (*a*) and (*b*) is approximately [2] equal to half the angle of repose (14°–18°) and is of course stable at smaller angles. Condition (*c*) is very common in nature, and this steady seepage state is not quite as unstable as conditions (*a*) and (*b*). Hence a sand slope which is just stable against rapid drawdown is slightly more stable against steady ground water seepage from within the slope.

An example of steady ground-water seepage from a fine sand leading to progressive internal erosion and undermining of overlying strata is given at the end of this paper. Seepage instability due to ground water flowing from within the slope may be produced in fragmental materials of any size theoretically, provided there is a sufficient head and supply of water. Such conditions may occur in constructional operations and cause instability in gravels. But in nature gravels are stable. When a fine sand is washed out from a slope it is loosely packed and over-saturated; it behaves as a quicksand and flows away as a heavy liquid, or even as a suspension. This eroded material then finds great difficulty in settling down and building up a flatter stable slope and before it has travelled far it may be picked up by other transport. However with a coarser material, like gravel, the quick condition never arises and a flatter stable slope is immediately built up from base level.

The action of rapid wave oscillations on a sand slope may be to surpass condition (*a*) and produce a surface suspension with no intergranular stresses leading to even flatter slopes. The problem in fact can no longer be considered from the point of view of statics. It is however interesting to compare con-

[1] 'Terzaghi, K., 'Theoretical soil mechanics,' pp. 249 and 255. New York, 1943.

[2] The strict relation is $\tan \beta' = \frac{\rho - 1}{\rho + \epsilon} \cdot \tan \phi$, where

β' is the stable slope under drawdown conditions,
ρ is the density of the sand grains (2·65), and
ϵ is the void ratio (volume ratio of voids to solids).
ϕ is the angle of internal friction of the sand.
ϵ may vary from 0·4 dense to about 1·2 loose and hence $\tan \beta' = 0{\cdot}43$ to 0·54 $\tan \phi$ for silica sand.

dition (*a*) with the work of Bagnold,[1] in particular with the shingle beach angle. The field observations of Agatz[2] show that where the submerged sand slope is $\beta = 26\frac{1}{2}°$, the rapid drawdown slope (beach angle) β' is 13°, or approximately $\beta/2$.

Rotational shear slips.—This type of failure appears to be fundamental in cohesive strata and it is probably the commonest type of slope failure in this country. The mechanism of the movement took many years to be appreciated. It is recorded at least as early as 1844 in this country by Gregory [3] and two years later by Alexandre Collin, an engineer on the Bourgogne Canal, who, in addition to understanding thoroughly the movement, also measured the shear strength of the clay. This important work received little attention, although Forbes,[4] following Collin, suggested that such movements occurred in glaciers. Recent observations by Haefeli [5] again support this type of movement in glaciers, and some of the steeper glaciers I have examined suggested a succession of these movements. It was not until 1915 that Pettersen and Hultin [6] developed a simple method of analysis in connection with a quay wall failure at Göteborg. This was followed by a large number of field observations on rotational slips by the Swedish Geotechnical Commission 1922.

The movement is, briefly, a rotational one with minor distortion of the moving mass. The characteristic surface features are a crack and a drop at the top with backward tilting and upheaval at the toe. Some of the clearest illustrations seen of this movement come from recent work in the Fens carried out by the Building Research Station.[7] A study of these movements provides an interesting example of the link between the hydraulics of the river and the stability of its banks. The new Flood Protection Scheme for the Fens recently adopted by the River Great Ouse Catchment Board has been described in the *Journal*.[8] We have been investigating the stability of the banks of the proposed new cut, 9 miles long between Denver and St. Germans, and have studied several of the slips on the banks of the adjacent tidal river Ouse. The banks of this river are more or less unstable throughout its tidal region, except downstream from King's Lynn where the banks have recently been flattened and pitched.

[1] Bagnold, R. A., "Beach formation by waves; some model experiments in a Wave Tank." *J. Inst. Civ. Engrs.* 15 (1940) 27.

[2] Agatz, A., 'Der Kampf des Ingenieurs gegen Erde und Wasser im Grundbau.' Berlin, 1936.

[3] Gregory, C. H., "On railway cuttings and embankments; with an account of some slips in the London clay, on the London and Croydon Railway." *Min. Proc. Instn. Civ. Engrs.* 3 (1844) 135.

[4] Forbes, J. D., A letter on glaciers to Dr. Whewell dated 2 December 1848 published in *Edinburgh Phil. J.* January 1849; also in 'Occasional papers on the theory of glaciers,' Edinburgh, 1859.

[5] Haefeli, R., "Zur Mechanik aussergewöhnlicher Gletscherschwankungen." *Schweiz Bauztg.*, 115 (1940).

[6] Pettersen, K. E., "Kajraset i Göteborg den 5 Mars, 1916." *Tekn. Tidskr.* 30 (1916) 281; 31 (1916) 289; and Hultin, S., "Grusfyllningar för Kajbyggnader." *Tekn. Tidskr.* 31 (1916) 292.

[7] The author is indebted to Mr. W. E. Doran, Chief Engineer of the River Great Ouse Catchment Board, for allowing him to publish this information.

[8] Doran, W. E., "The Ouse flood problem." *Geogr. J.* 97 (1941) 217.

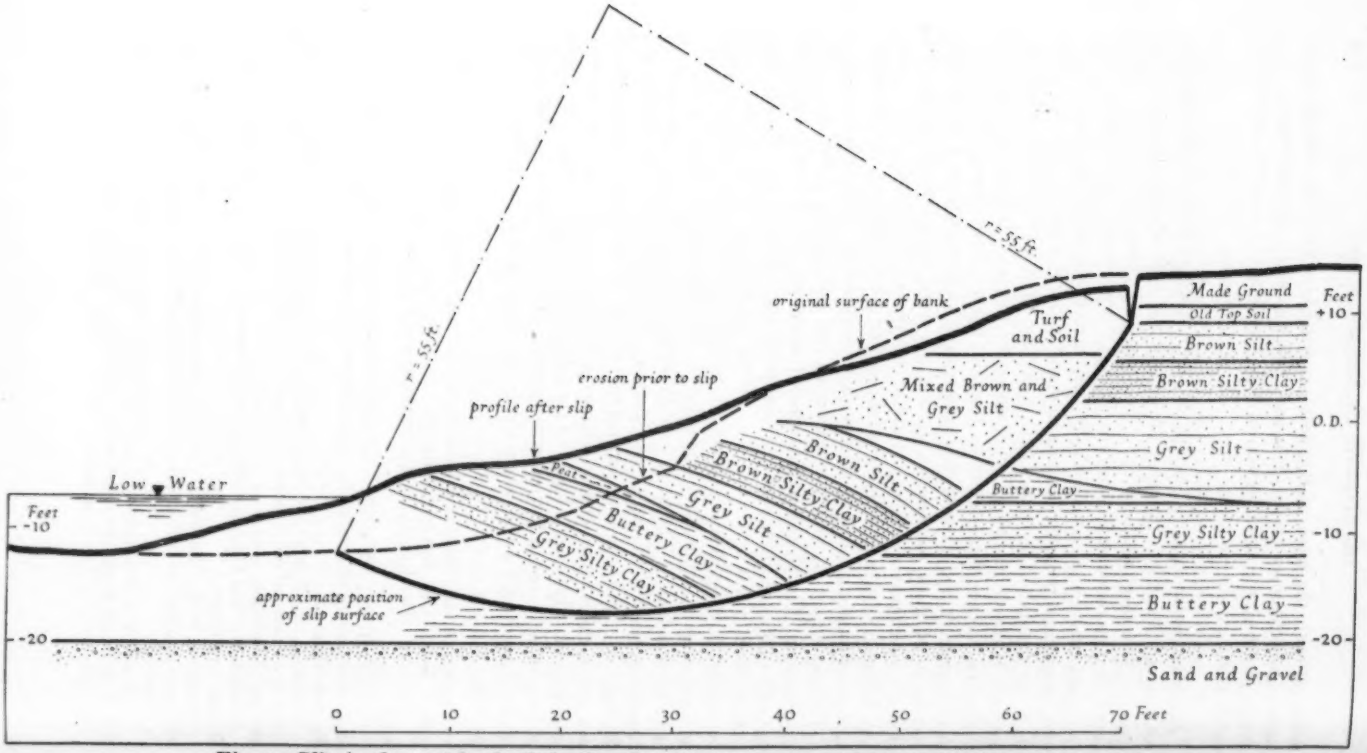


Fig. 2. Slip in the west bank of the Eau Brink Cut near Free Bridge (after Skempton, 1945)

Generally the river causes erosion towards the toe of the bank and fine silty sand brought in from the Wash is deposited at about high tide-level on the upper part of the bank. There is then undercutting and deposition occurring, and both processes are tending to steepen the bank slope. A critical slope is ultimately reached when the bank fails, with a rotational movement, which ceases when the toe has lifted sufficiently. Fig. 2, which is redrawn from sections given by Skempton,[1] shows a slip three months after its initial movement.

Unfortunately, the traditional method of maintaining the banks is speeding up this failure cycle. The lost ground at the top of the bank is made up with earth, while faggots are used to face the bank above low water-level and this encourages silt to be picked up from the river more rapidly. Hence the repair process is never ending. It is not known when this method of repairing the banks with faggots was introduced into the Fens; it may have come from Holland. It appears however that in Holland, when the rivers erode at the toe of their banks that they sink mattresses.[2] Possibly it was thought that the movements were entirely near surface, in which case the faggots probably would be of some assistance. It has been noticed that a certain amount of surface movement of the deposited silty sand does occur each time the tide falls, nevertheless about a foot of silt may easily cover the tops of the faggots in a few months. The bank failure process taken to its ultimate state is shown by the section of a much older slip in Fig. 3. Here the normal Fen strata have been entirely replaced by river silt and faggots. An interesting feature is that the shear strength of the replaced silt is only about half the strength of the original Fen strata and consequently the stable slope is flatter.

It has been proposed that in future these slips should be treated by tipping gravel or pitching at the toe to prevent undercutting of the bank and improve its stability. Experimental sections covering active slips are to be carried out on these lines.

The Stability Analysis of Rotational Shear Slips: The method used for estimating the stability of slopes of cohesive materials is indicated only briefly to show the general approach to the problem.

A rigorous analysis should be based on the true angle of friction and the true cohesion of the material, and on the actual effective stresses acting between the particles at the slip surface. This is not possible at present and it is necessary to make certain simplifications, one of which is to assume that the strata behave as purely cohesive materials, with no frictional properties, and with an apparent cohesion equal to the existing shear strength as measured by tests on undisturbed samples. This method is known as the $\phi=0$ analysis. It is simple and straightforward and has proved a reliable practical method of estimating the stability of cohesive strata. There is evidence (Skempton, 1945) however that while this method gives a reliable estimate of the factor of safety, it does not necessarily define the position of the slip surface with accuracy, particularly in silty materials which indicate frictional properties when tested.

First, the existing shear strength of the various strata are measured by tests

[1] Skempton, A. W., "A slip in the west bank of the Eau Brink Cut." *J. Inst. Civ. Engrs.*, May 1945.

[2] Law, H., 'The rudiments of civil engineering,' 7th Ed., pp. 193–4, London, 1882.

Fig. 2. Slip in the west bank of the Eau Brink Cut near Ers. Bridge (after Skempton, 1945)

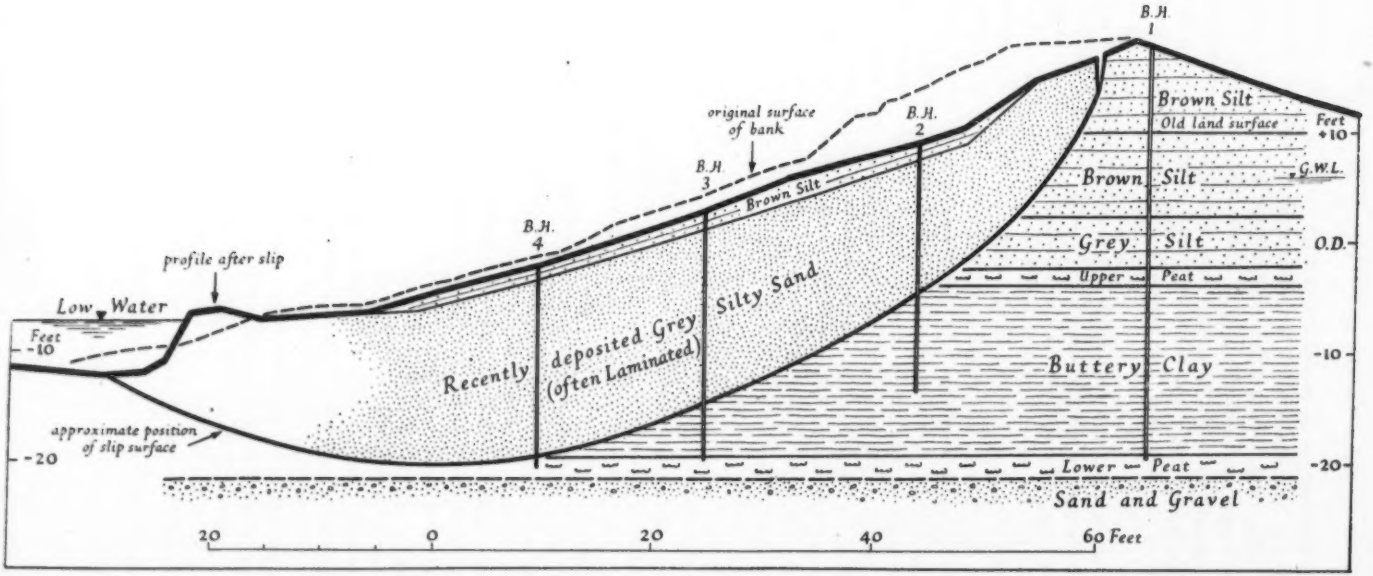


Fig. 3. Slip in the east bank of the river Ouse, near Wiggenhall St. Peter

on undisturbed samples.[1] Then a section of the slope on a natural scale, together with the various strata details, is drawn out. Trial slip circles are taken and the moments of weight and shear resistance of the material bounded by each circle are equated to find which circle gives a minimum factor of safety (see Fig. 4). This circle is known as the critical circle and the corresponding factor of safety indicates the degree of stability of the slope. Fig. 4 also shows curves which have been evaluated mathematically by D. W. Taylor for uniform slopes in uniform cohesive strata.[2] These curves relate the stability number $S/F\gamma H$ to the slope and a limiting depth factor, and are very useful for rapid estimates of slope stability. In varying strata it is often sufficiently accurate to take a mean shear strength and use these curves. The general results of these curves are of interest. If the slope angle is greater than about 50°, then the slip circle passes through the toe of the slope and the limiting depth is not critical. When the slope is less than about 50°, the slip circle generally passes below the toe, tangential to the firm stratum, and then when the depth factor is large, the slope is not critical until it is less than about 15°.

It should be clear from Taylor's curves that the stable slope in any stratum which has the slightest cohesion is dependent on its height, in contrast to granular materials where stability is independent of height. It is however impossible to scale the stability of cohesive slopes of different heights without introducing changes in the properties of the material.

In nature, the slip surface always tends to pass along the weakest stratum and, when this stratum is thin compared with the height of the slope, the slip surface departs seriously from a single circle. It is then necessary to proceed to more elaborate analyses, using for example two circles.[3] With slopes exposed to slow atmospheric weathering the material softens from the exposed surface and this may restrict the depth of movement to slip surfaces at or above the toe even when the slope angle is much less than 53°. This is so with the Sevenoaks slip on a slope of 26½°. When the strengths of the strata are markedly different parallel to the slope, the failure movement practically looses its rotational form and it slides more or less parallel to the slope. Such conditions also arise on slopes thinly covered with softening cohesive detritus. These movements are referred to later.

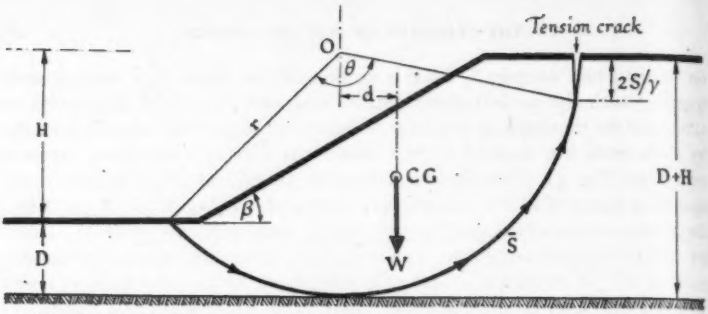
Examples of Rotational Shear Slips: The slip which occurred in Weald clay at Sevenoaks in 1939 [4] is typical of the numerous weathering failures which occur in railway cuttings in this country. While this is a slip in a man-made cutting, it is considered that similar phenomena happen in nature. Plate 4 (p. 187) shows this slip with some of the toe material being cleared from the track. The cutting, which is 60 feet deep, was made seventy years earlier with side slopes of 1 on 2. The coombe-shaped form of this slip is typical, and often

[1] Cooling, L. F., "Soil mechanics and site exploration." *J. Inst. Civ. Engrs.* 18 (1942) 37–61; and Cooling, L. F., and Golder, H. Q., "Portable apparatus for compression tests on clay soils." *Engineering*, 19 January 1940.

[2] Taylor, D. W., "Stability of earth slopes." *J. Boston. Soc. Civ. Engrs.* 24 (1937), No. 3.

[3] Cooling, L. F., and Golder, H. Q., "The analysis of the failure of an earth-dam during construction." *J. Inst. Civ. Eng.* 20 (1942) 38–55.

[4] Toms, A. H., "Soil mechanics and the civil engineer." *Rlwy. Gaz. Lond.* 78 (1943) 242.



(a) Simple circular arc method of estimating the stability of a clay slope

H = *height of slope in feet*
β = *inclination of slope*
D+H = *depth to firm stratum in feet*
W = *weight of rotating mass in lbs.*
$\bar{S}$ = *average shear strength of clay along arc of failure in lbs. per sq. ft.*
γ = *density of clay in lbs. per cub. ft.*
$n_D = (D+H)/H$
CG = *centre of gravity of rotating mass*

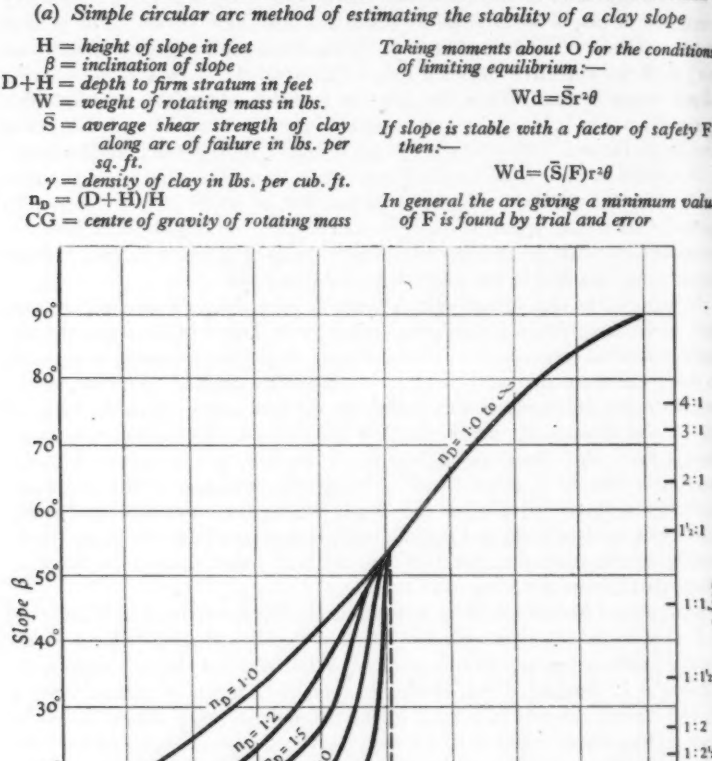
Taking moments about O for the conditions of limiting equilibrium:—

$$Wd = \bar{S}r^2\theta$$

If slope is stable with a factor of safety F, then:—

$$Wd = (\bar{S}/F)r^2\theta$$

In general the arc giving a minimum value of F is found by trial and error



(b) Curves relating the stability number, slope, and depth factor for homogeneous clay slopes (after D. W. Taylor, 1937)

Fig. 4. Circular arc analysis of clay slopes

a whole series of these coombes develop as in the London clay slips on the north coast of the Isle of Sheppey. There the coombes are separated along the coast by striking knife-edge aretes in the slightly cemented sands which overlie the London clay.

The most interesting feature of the Sevenoaks slip is that the failure occurred so long after excavation. It suggests that a gradual weakening of the clay had been taking place and this was found to be the case. The slip was stabilized by placing deep rubble drains down to below the slip surface. These deep drains are usually regarded as increasing the strength of the clay by gravity drainage, but the evaporation by air circulation is probably appreciable and there may be a small strengthening effect due to replacing part of the slip surface with stronger material. In the course of digging these drains it was found that in many places the softening had proceeded to a stage at which the original hard clay existed only as lumps in a matrix of soft plastic clay. The strength of this clay was estimated to be only about one-eighth the strength of the original clay.

The explanation of the softening process is roughly as follows.[1] The phenomenon occurs chiefly in what are called stiff-fissured clays. These are clays which have been heavily compacted in the geological past and from which the load has subsequently been removed by denudation. The fissures are readily revealed if a lump of this clay is dropped, when it breaks up into polyhedral fragments. When a deep cutting is made in this material some of the load is removed from the flanks and base of the cutting and the fissures can open slightly. The exposed clay begins to swell and take up water, and it does this chiefly along the fissures. Gradually softened films develop along the fissure surfaces and the material is seriously weakened. This softening slowly proceeds to equilibrium under the new loading conditions. If the ultimate equilibrium strength of the clay is less than that required to sustain stability of the slopes as cut, a slip will occur. It is evident therefore that if the cuttings are to stand up for many years allowance for this progressive softening must be made in design. In the laboratory the equilibrium shear strength under any load may be measured by placing a $\frac{1}{2}$-inch thick prism of the original clay between loaded water saturated porous stones and allowing it to swell and take up water. Equilibrium is reached in one to two days and the shear strength of the block may then be measured and this value used in design.

This softening phenomenon associated with fissuring occurs in nearly all the old clays of this country, *e.g.* London, Gault, Weald, Kimmeridge, Oxford, and Lias clays, and even in the older clay shales. Unloading and subsequent softening on a larger natural scale due to valley formation by ice or river erosion has no doubt been the origin of some of the very old landslips encountered by the geologists in the hilly districts of this country.

One of the coastal landslips which has been explored in most detail is the Warren at Folkestone.[2] The strata here consist of chalk overlying Gault.

[1] Terzaghi, K., "Stability of slopes of natural clay." *Proc. Int. Conf. Soil. Mech.* 1 (1936) 163.

[2] The author is indebted to Mr. V. A. M. Robertson, Chief Engineer, and Mr. A. H. Toms of the Southern Railway for allowing him to publish the information relating to Sevenoaks and Folkestone Warren.

The Gault dips from west to east and also slightly inland. It is only whe the Gault is exposed to sea action that the landslips occur. About 3 miles coast line are involved and some ten major movements have taken place sinc the middle of the eighteenth century.[1] Pl. 1 is a general view looking we towards Folkestone. The railway line between Dover and Folkestone can b seen cutting through the middle of the slip and this is probably why th Warren is so well known.

A generalized section through the slips is given in Pl. 2 which has bee constructed from borings carried out by the Southern Railway. The funda mental cause of the slips is the sea erosion of the Gault at the toe. This allow deformation to occur which fractures the chalk and a slip takes place by shear ing right through the Gault. The stability is reduced by hydrostatic pressur from water in the joints and fractures of the chalk. From samples taken in th borings it has been found that the Gault in the immediate vicinity of the sli surface has a strength only a fraction of that of the undisturbed clay. Thi reduction in strength is probably due to unloading, causing swelling an softening of the clay, as mentioned in connection with the Sevenoaks slip, bu in addition water from the chalk is probably worked into the clay during shea movement. Drainage of the chalk is therefore helpful and this has been carrie out by driving many adits.

It should be noted, Pl. 2, that the slip plane penetrates the full thickne of the Gault and there is no suggestion that the chalk is sliding down the sur face of the Gault. The rotational movement always tends to leave a steep back face, which is generally unstable, and in Pl. 1 a recent chalk fall may b seen. In stabilizing these movements it is necessary where possible to reduc the slope of the newly exposed back face, as was done at Sevenoaks.

After a slip has occurred at Folkestone the rotating mass builds up at the to and forms islands, see Pl. 3, and the slope becomes stable, until the sea washe it away. It is clear then that prevention of erosion at the toe is vital and wor along these lines has been undertaken by building a sea wall and encouragin deposition with groynes.

The movement of the famous Axmouth landslip [2] is rotational and i generally similar to that at Folkestone. The stratigraphy is practically th same in both cases, but at Axmouth the underlying clay is Lias. The back ward tilting and the upheaval in the form of a reef more than a mile in length and rising more than 40 feet is recorded, but it was incorrectly inferred that the movement of the overlying chalk and Greensand was one of sliding on the surface of the Lias.

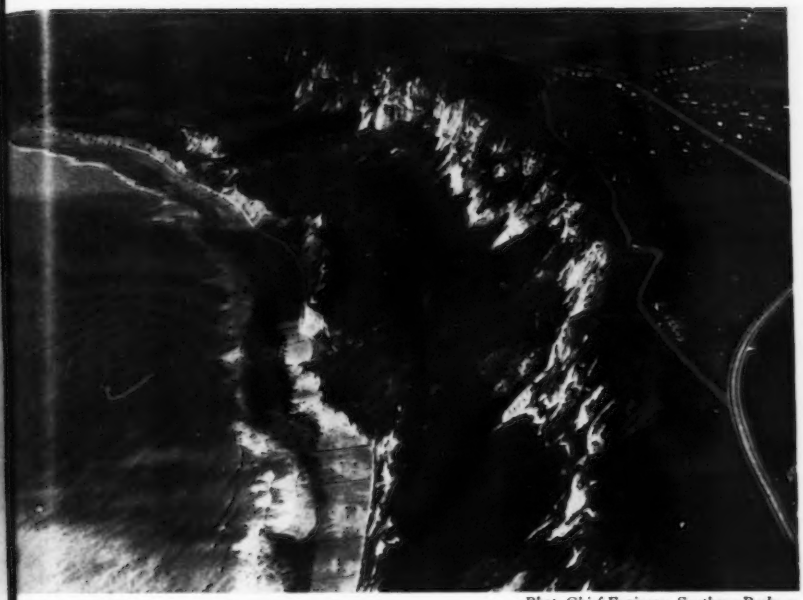
The cambering and valley bulging which has recently been mapped in the Northamptonshire ironstone field [3] and the valley bulging which has been recorded from time to time in dam cut-off trenches in the Midlands and North of England [4] are features which are very similar to those produced in a more

[1] Osman, C. W., "The landslips of Folkestone Warren and thickness of the Lower Chalk and Gault near Dover." *Proc. Geol. Ass. Lond.* 28 (1915) 59.

[2] Lyell, C., 'Principles of geology,' 9th Ed., pp. 321–22, London, 1853.

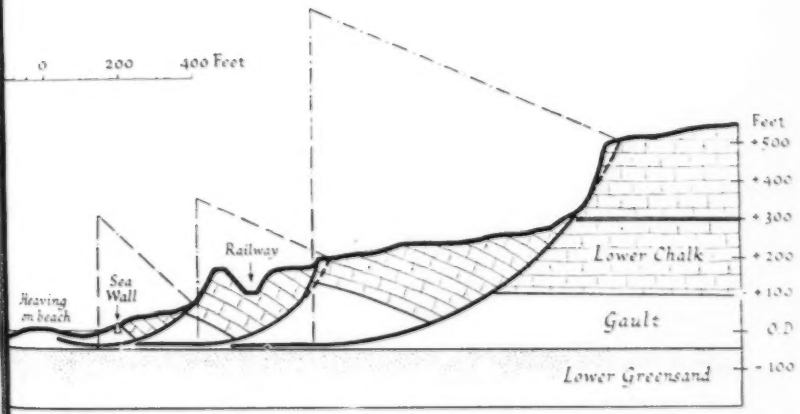
[3] Hollingworth, Taylor, and Kellaway, "Large scale superficial structures in the Northampton Ironstone Field." *Quart. J. Geol. Soc. Lond.* 100 (1944) 1.

[4] Dawkins, W. B., Discussion on "The Derwent valley waterworks," by E. Sandeman. *Min. Proc. Inst. Civ. Engrs.* 206 (1920) 190.



Phot. Chief Engineer, Southern Railway

. Rotational shear slip and chalk rockfalls at Folkestone Warren, looking west



Generalized section through Folkestone Warren showing probable mechanism of slips

Phot. Chief Engineer, Southern Ra

3. Upheaval of Gault Clay forming islands at Folkestone Warren

Phot. Chief Engineer, Southern Rail

4. Rotational shear slip in Weald Clay, Sevenoaks

sudden manner by rotational shear slips. The distribution of stresses in the ground is generally the same in both cases, for it is only a problem in geometry, and does not depend on the absolute size. Whether the stresses are sufficient in magnitude to produce shear failure towards the base depends on the shear strength of the rock in relation to its weight and height of slope. Presumably considerable creep can be expected over long periods in rocks, as in most other materials, through stresses well removed from failure. It is often noticed when carrying out compression tests on small clay samples that slow progressive deformation occurs if the test is interrupted well before failure is reached.

The gulls and dip-and-fault structures so carefully recorded by Hollingworth and others are reminiscent of the features that occur in the tension zone at the tops of rotational shear slips. The bulk tensile strength of most rocks is low and it is usually neglected by engineers in design. Normally the state of stress in a slope due to its own weight does not favour the formation of tension cracks to a depth greater than half the height of the slope, and for purposes of estimating stability their depth is taken as equal to $2\bar{S}/\gamma$, see Fig. 4.[1] When the tension movement becomes appreciable the material adjacent to the cracks may be subject to weathering and it may shear off and fill up the bottom of the crack. This is a common occurrence in rotational shear slips.

It is interesting to compare the Northamptonshire valley bulges with the bulging which occurred in a cutting at Rapperswil, Switzerland.[2] About 5·5 metres of firm surface strata was cut through, this fractured downwards at the sides and squeezed up the underlying soft blue clay apparently without forming slip planes.

Rockfalls and slides.—Under this heading the term rock is restricted in its meaning to hard rock and does not include sediments such as clays and uncemented sands and gravels. The results of movements associated with steep rock exposures where not underlain by weaker materials, which may control mass stability, can be seen in any mountainous district. These movements have been studied qualitatively in some detail in the Alps.[3] The freezing and thawing and subsequent waterlogging of the exposed joints of rock is usually the cause of movement. The material once disturbed mainly falls and rolls freely and scarcely any shear resistance is encountered. The large scree slopes in the Lake District and elsewhere are the remains of such rockfalls. Occasionally exceptionally large pieces of rock become detached and on reaching the scree sufficient momentum is imparted to start a large mass of scree moving. This scree shoots down and across the valley and comes to rest in a somewhat flow-like form. There are many such "rock streams" in the San Juan mountains, Colorado.[4] The large rockfall at Elm, Switzerland,

[1] Terzaghi, K., 'Theoretical soil mechanics,' pp. 173–75, New York, 1943.

[2] Moser, R., "The so-called landslides at Rapperswil." *Schweiz. Bauztg.* 24 (1894) 40–45; and Terzaghi, K., Chapter on "Landslides" in 'Ingenieurgeologie,' by Redlich, Terzaghi, and Kampe, Vienna, 1929, p. 424.

[3] Heim, A., "Bergstürz und Meuschenleben." *Naturf. Gesell. Zürich*, 77 (1882) 218 pp.

[4] Howe, E., "Landslides in the San Juan Mountains, Colorado." *Prof. Pap. U.S. Geol. Surv.* 67, 1909.

1881, caused by the roof of a quarry collapsing,[1] produced a similar rock stream.

Rockfalls may also be due to undercutting of cliffs by the sea or by rivers. The falls of chalk along many stretches of the South coast are typical examples. With undercutting, overhangs may be produced and the falls often occur in quite large masses at fairly long intervals, whereas the rockfalls caused by atmospheric weathering usually come down in smaller fragments more frequently.

Bedding planes and other weaknesses, such as fault zones and thin cohesive beds dipping towards the slope, may be slowly weakened by frost and water, until eventually the superincumbent rock slides down. In the opening out of the Cofton Tunnel [2] a series of parallel fault fractures were encountered, which led to several serious slides and increased the estimated excavation by nearly 30 per cent. The gigantic rock slide at Goldau, Switzerland, in 1806 (Heim 1882), involved the movement of a rock slab 1500 metres long, 300 metres wide, and 32 metres thick (about 15 million cubic metres) sliding on a bedding plane sloping at 30°.

Detritus slides.—Detritus slides are shallow movements in cohesive materials. They are restricted in depth by an increase or marked change in the strength of the material. The depth involved is often of the order of one-twentieth or less of the length of the moving slope. Below this level the ground does not move, while above the rate of movement may increase considerably towards the surface. This is in contrast to the rotational shear slips where the displacement parallel to the slope generally increases with depth towards the slip plane.

Most of the examples of detritus slides on record occur on clayey talus slopes. The upper shale outcrops weather and fall down in fragments to form the talus slope. This debris being full of air spaces is free to expand, take up water, and soften until a state is reached when its shear strength is sufficiently reduced for a slide to occur under the action of gravity. The troublesome slides in the Moutier-Court gorge, Switzerland [3] are typical examples. Three slides have been recorded here in 1770, 1844, and 1937 on both sides of the gorge and the road through the valley has been moved from one side to the other and back again without avoiding blockages. The most recent slide in 1937 is shown in section in Fig. 5. The movement of about 150 feet on wooded slopes occurred after exceptionally heavy rainfall, and the slide forked into two separate tongues, which dammed up the river Birse.

Detritus slides are invariably found at the weathered toe of old active rotational slips. Here the material is left badly cracked, which induces progressive softening and gradual deterioration until the material flows like mud. Mud runs are in fact only an advanced type of detritus slide and they occur

[1] Conway, W. M., 'The Alps from end to end,' Ch. XI. London, 1895.

[2] McCallum, R. T., "The opening-out of Cofton Tunnel, London, Midland and Scottish Railway." *Min. Proc. Inst. Civ. Engrs.* 231 (1930) 161.

[3] Peter, A., "Le glissement de terrain dans les gorges de Moutier-Court." *Strasse und Verkehr.* 24 (1938) 165–172, 184–188, 206–208.

chiefly in humid climates where the progressive softening takes place more rapidly.[1]

Detritus slides are difficult and expensive to stabilize. Their movement is generally not self-stabilizing as with slips of the rotational type and the material tends to collect in the valley floor. The only successful way of stabilizing them is to provide numerous deep rubble drains and descending surface water should be intercepted above the slope where possible. The degree of stability of a suspected slope can presumably be investigated by measuring the shear strengths of the material and then by trial and error the critical sliding plane may be found by summing up the resultant forces acting

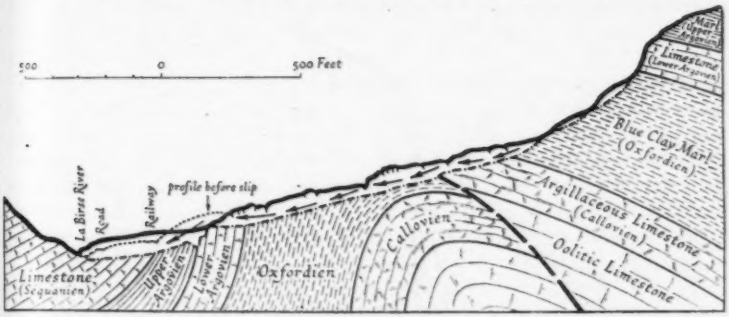


Fig. 5. Landslip in Jura mountains near Court, Switzerland (after A. Peter, A. Buxtorf, and L. Vonderschmitt)

up the slope. The progressive softening can probably be allowed for by measuring the equilibrium shear strength under zero normal load. This type of analysis does not appear to have been tried so far.

A landslip on the South Coast

A landslip caused by internal erosion of a sand bed has been left until the end of this paper because the movements are complicated and involve a combination of no less than three types of failure already described. A section through the landslip which is about a quarter of a mile long is shown in Fig. 6. The strata consist of a small outlier of the Woolwich and Reading Beds in full thickness overlying the Thanet Sand, which in turn overlies the chalk which extends to well below sea-level. The chalk cliffs here are comparatively stable at present and are generally protected from sea action by a good pebble beach. A hundred years earlier however the chalk cliffs were stated to be undermined and the greater part of an ancient entrenchment (part of which still exists) on the brow of the hill had been cut away by the sea. Movements similar to those described are mentioned in 1900. Some recent constructional work led to more vigorous movement and the work had to be stopped urgently.

The complete mechanism of the failure is not easy to follow and proved difficult to discover, but it probably consists of the following distinct types:

[1] Morum, S. W. F., "The treatment of mud-runs in Bolivia." *J. Inst. Civ. Engrs.* 1 (1935) 426–427.

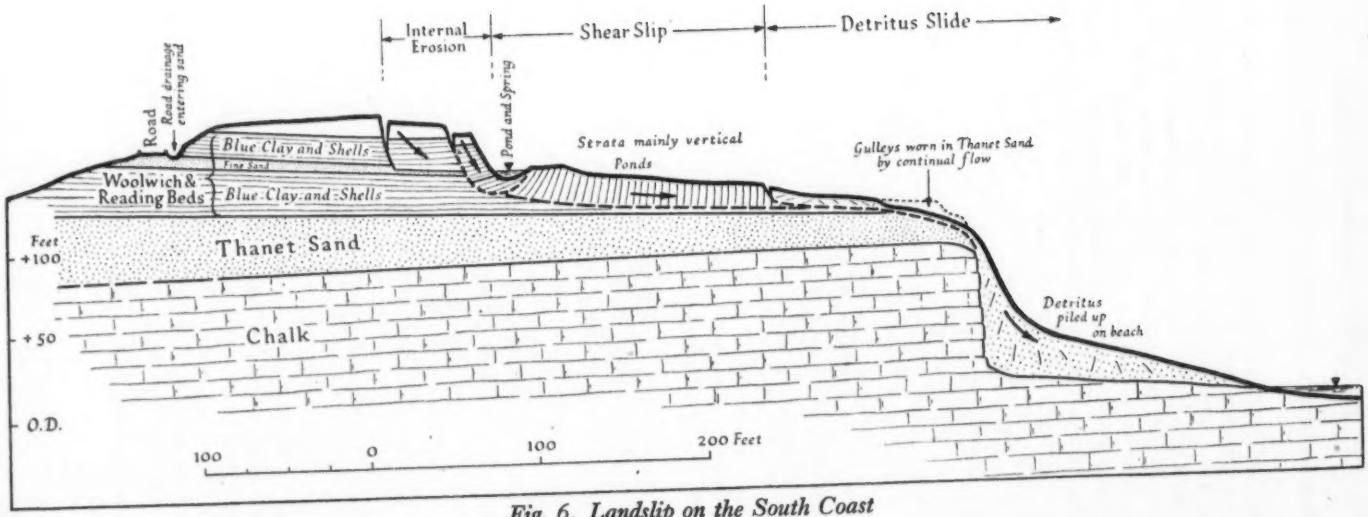


Fig. 6. Landslip on the South Coast

Internal erosion.—At about 30 feet below the hilltop is a layer of fine sand up to 6 feet thick interbedded with very thin layers of soft clay. The sand layer generally dips slightly seawards and water issues on that side bringing the sand out with it in a quick condition. A recently constructed road intersecting the sand layer on the landward side of the hill had appreciably increased the supply of water to the sand, by piercing the overlying soil and clay. The removal of the sand on the seaward face leaves the overlying stiff clay strata unsupported which tilts forward and breaks off rather like a cantilever.

Rotational shear slip.—The release of the upper mass of strata, some 30 feet high, imposes a heavier load on the clay below the sand layer, which together with the water induces a rotational shear slip. This water from the sand layer discharged throughout a very dry summer.

Detritus slide.—Owing to the vertical chalk cliffs below, the moving strata have no opportunity for building up a stabilizing toe. In fact the incessant streams of water from the sand layer seep into the highly cracked debris and soften it up until it is of the consistency of porridge. The rotational shear slip slowly merges into a detritus slide and pours over the cliff edge like mud and erodes gulleys in the Thanet Sand. An enormous accumulation of debris collects on the beach. In the summer a rock-hard crust forms on the debris.

The remedial measures over an area about 300 by 100 yards were carried out rapidly in three summer months and have been encouragingly successful after two winters. They consisted essentially of three parts. Where practicable the entry of water into the sand was stopped by sealing with concrete and puddle clay; many points of entry were inaccessible or unknown. A protective sand filter was arranged to cover the discharge face of the sand layer, where it was not covered by landslip blocks. This is a very useful device which simply allows the water to escape without washing out the sand grains. It consists of a layer or series of layers of coarse sand and gravel with similar grading curves as the original sand but successively about four times as coarse. These layers need only be about 12 inches thick and the velocity of the water is reduced sufficiently for the outer layer to be undisturbed by the flow of water. The water from the filters was discharged through deep trenches filled with brick rubble, which provided the main stabilizing factor for the lower sliding masses. These drains descended below the slip planes. All the soft debris around the gulleys was thrown over the cliff and partly replaced by brick rubble. During the digging of the deep trenches it was found that the original horizontal strata had become vertical and even back-tilted and several repetitions of the strata were seen.

In connection with the preparation of this paper the author wishes to acknowledge the kind assistance of his colleagues at the Building Research Station—in particular valuable discussions with Mr. A. W. Skempton.

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DISCUSSION

Before the paper the CHAIRMAN (Mr. LEONARD BROOKS, Vice-President), said: In recent years the Building Research Station at Garston, near Watford, has been investigating problems connected with the stability of earthworks and foundations. This is primarily the concern of civil engineering, but the results can be applied to geographical and geological problems arising from the stability of natural slopes. It is with this aspect that Mr. W. H. Ward, a member of the staff of the Station, is to deal this afternoon. After discussing the general principles involved, he will describe particular examples, such as cliff falls and coastal erosion, the erosion of river banks, and the internal erosion of sands. We look forward to an interesting paper and to a profitable discussion.

Mr. Ward then read the paper printed above, and a discussion followed

The CHAIRMAN: We, fortunately, have several who will take part in the discussion. First I call on Dr. Hollingworth.

Dr. S. E. HOLLINGWORTH: It is a pleasure to have the opportunity of hearing Mr. Ward's paper and of adding one or two remarks from my own experience. During the last four or five years my colleagues and I in the Geological Survey have been making 6-inch maps of the whole Northamptonshire Ironstone Field, and among our results is the recognition of large-scale superficial movements which have taken place there. These are of interest to us here because they have some bearing on the question of the origin of landslides.

We noticed that when a valley is cut down through the Ironstone and through the overlying Lincolnshire Limestone, near to or into the Lias clay below, there are marked disturbances in the lower part of the valley which are attributable to the excess weight on the sides of the valley, acting on the incompetent clay forming the valley floor. The differential loading has led to a squeezing or bulging of clay upwards in the valley bottom. Where the whole of the valley is carved out of Lias clay there are some related phenomena on the lower slopes. Here the movement in the relatively weak clay is mainly a lateral one from the valley side towards the centre of the valley, and there are in consequence near surface movements in the valley bottom, resulting in the formation of small folds in the Lias clay with marked overturning towards the valley.

These movements in clay have a bearing on the origin of certain other structures that we found in the Ironstone Field. There the Ironstone caps much of the high ground, the lower slopes of the valleys being on the Lias clay. In a horizontal section showing the geological structure of the district one might expect a normal scarp and long dip slope. In practice we found something quite different. Instead of a steady and gentle inclination or dip persisting up to the top of the escarpment, we found the beds turning over on the scarp and taking on the reverse dip towards the valley. In certain artificial exposures on such a valley side we found the clay to have, not a normal bedded structure, but to be made up of a series of small clay pebbles 2–3 inches in diameter in a matrix of unbedded sheared-up clay. It is evident that there has been internal movement with a zone characterized by a sort of general crumbling or break up of the clay beneath the hill, that seems to be related to a general movement towards the valley. This structure is similar in many ways to what has been found on a very large scale in the Tertiary rocks of Peru where there have been large-scale slides forming low-angle breccia zones or clay pebble beds extending for miles beneath the Andean foothills.

Higher up on the sides of the Northamptonshire valleys, quarries in ironstone show that there has been considerable movement causing a breaking up of the ironstone bed into short lengths or unit blocks which individually dip down

slope and are separated by small faults with downthrow on the uphill side. This fracturing is part of a process of adjustment to extensional movement for which there is ample independent evidence. An analogy might be drawn between these structures and that of a glacier in which the crevassed upper portion overlies a lower zone characterized by viscous or semi-fluid flow.

These facts lead to a suggestion as to the origin of landslips. The joints or fissures in the zone of fracture will be liable to let in surface or sub-surface water down to the level of what, generally, may be referred to as the zone of flowage in the clay. This access of water to the clay would tend to soften and weaken the upper part of already weak shear zone of the clay pebble bed. The result is that at this level there is a strong tendency for the overlying mass of rock and clay to move outwards. With increased access of water a well-lubricated slip plane develops and landslipping ensues. It will be evident that the opening of the fissures in the stiff fissured clays, due to relief of pressure consequent on erosion, as described by Mr. Ward, may play an important part in these processes by facilitating the access of water. I am however inclined to think that internal distortion and movement within the least competent material on a slope has a more significant role in the initial stages of landslipping than he appears to allow.

I would also like to draw attention to, and invite Mr. Ward's comment on, some extremely interesting landslips which my colleague, Dr. Welch, has studied in the Abbotsbury area of Dorset. These are shown in plan on his geological map of the area. Landslip belts extend for three-quarters of a mile outwards from the Greensand scarp. They occupy large areas, some 10 or 12 square miles on one 1-inch map, in which the solid topography is completely obscured by the great belts of slipped material. In a cross section of one of the most outstanding instances a large outlier of Greensand has almost disappeared as a result of the landslip. It is now represented by long stretches of landslip material extending for half a mile or more on each side leaving a narrow ridge that can be likened to a steep arete formed by glacial plucking from two sides.

I should like to hear Mr. Ward's opinion as to the behaviour of the underlying Gault clay in this area. It has a silty character and seems to behave, to some extent, as in those examples to which he has referred where there is some washing out of the material and not so much yielding due to failure under shearing stresses.

Dr. W. D. Evans: In extending my congratulations to Mr. Ward for his account of researches on landslides and allied phenomena, I should like to bring to his notice an area to which his work could be extended profitably. I have in mind the central and eastern parts of the South Wales Coalfield, where enormous landslides, some quite recent, have disrupted rail, canal, and road communications; and in some cases partly engulfed mining villages. Of these little has been published since the appearance of Professor Knox's paper in the *Proceedings* of the South Wales Institute of Engineers (43 (1927) 161–247, 257–291). In this work many of the examples quoted by Mr. Ward from foreign sources have been described. It was therefore with some surprise that I heard from Mr. Ward that mud-flows, for example, were extremely rare in this country; for Knox describes several. Knox, rightly I think, attributes these mud-flows to lubricating spring and surface waters acting on the underside of (as well as making more plastic) the superficial deposits of clay, rock-rubble, and shale which blanket the sides of the deep valleys in the South Wales Coalfield. When the cohesion of these superficial deposits to the underlying solid strata has been destroyed by seepages of water they move downhill as mud-streams similar to those described by Mr. Ward. Apart from rain-water, the

bulk of the water is obtained from the many springs which emerge at the junction of the impervious Lower Coal Series and the overlying pervious Pennant Sandstone Series. In the Tillery Vein, for example, old crop workings situated high up on the hillside, have accentuated the emergence of water derived from the overlying Pennant Series. This water saturated the blanket of superficial deposits situated below the adit entrance, upon which a reservoir had been constructed. First a crack appeared in the ground above the reservoir. This was followed by another behind the dam, and then the inevitable landslide occurred.

Rock-slides of all kinds occur in these mining valleys. I suggest they afford clear examples of landslides induced by the action of percolating waters. In the majority of cases the water reduces the frictional, or cohesional, force which would normally allow scree and other superficial deposits to remain at the foot of the rocky crags high up on the valley sides. The toe of the open-jointed crags of sandstone is supported by these superficial deposits, but when they move downhill movement is induced in the solid Pennant Sandstone and eventually a rock-slide results. In other cases the water from the Pennant Sandstone penetrates, and makes more plastic, the underlying shales and fireclays of the Lower Coal Series. This renders unstable the foundations of the crags of open-jointed Pennant Sandstone and deep-seated rock-slides occur.

In addition to landslides caused by natural agents of denudation, we have in South Wales examples of landslides which are partly induced by subsidence after mining. Thus any further research on these problems which can be applied to South Wales would be welcome, for on the stability of the valley-sides and the possibilities of movement in the valley-floors will depend the planning of housing schemes and factory sites in these narrow, industrialized valleys.

Mr. REGINALD BEE: I would like to associate myself with the congratulatory remarks on Mr. Ward's paper because to me this subject is of profound interest. For many years I have been building roads and railways in the tropical Colonies. There we have had to learn as we went along by the experience of what happened if we disturbed some of the hill-sides.

We have in the Colonies many problems. One is in connection with the magnificent granite domes which are so characteristic of Central Africa. In dessicated regions such as northern Nigeria the rock weathers by exfoliation leaving bare rock domes and the engineering problems are those of location and heavy blasting. Where the climate is more humid, as on the coastal belt of West Africa and certain parts of the Far East, such as Malaya, the rock is converted into lateritic clay by the intensity of the tropical decomposition. This decomposition extends, in many cases, to a depth of well over 100 feet.

The original granite domes may have had slopes which were extremely steep. The decomposition product of clay, by virtue of the vegetation, has managed to cling on to some of these very steep slopes, so that the slopes appear fairly stable. Water does not apparently get down on to the solid area until we engineers come along and start cutting out roads and railways along the steep slopes. Usually then we see a most spectacular slip. Occasionally all three forms of slips mentioned by Mr. Ward occur together: the surface flow, the classical turning failure, and the deep-seated movement.

One of my first experiences in Singapore in 1922 was when we cut out a fairly deep excavation at the classical 1 to 1 slope for a road through a decomposed shale. This slope failed badly. We did not lose any lives or machinery, but there was a nasty mess in the bottom of the cutting. We cleared that out and were surprised to find that the vertical slope at the top of the slip remained standing. It was certainly still standing well over twenty years later. I can only suggest that the reason for this is that the shear strength of the decomposed shale is greater

along the planes of foliation than across them. I have not actually tested this, but I would ask Mr. Ward whether he has had any similar experience in such shales?

Dr. H. L. RICHARDSON: I should like to add a word or two from the point of view of soil erosion and conservation. Those interested in soil erosion in America are chiefly concerned with surface run-off or gullying, but there are some parts of the world in which landslips are most important. One is the North Island of New Zealand, particularly on tertiary clays which have been steeply cut by geological erosion. There are thousands of square miles where, following the clearing of the Bush, landslips have taken place, and the special circumstances that give rise to the landslips in New Zealand have drawn attention to that form of accelerated erosion, which is rather less known elsewhere in the world. As far as I remember the usual form of landslip in New Zealand is the flow slip. There is often a steep slope or even a bare scarp on the upper part of the hill, where the slip begins, and then it forms a sort of tongue of soft muddy material running out at the bottom.

Also I would draw attention to the importance of earthquakes in landslides, especially in relation to geological processes. I have been in two regions in recent years in which there have been major earthquakes, one in north-west China in Kansu, and one in the South Island of New Zealand near Murchison. In both places there was an immense number of landslips on the slopes of the hills, extending over some hundreds of square miles, which had obviously been brought on by the earthquake.

Dr. ALAN WOOD: I hope Mr. Ward will not think I am criticizing his work or that of his colleagues unduly when I suggest that the paper would seem to be incorrectly named. Surely it should not be "The stability of natural slopes," but "The disturbance of stable slopes"?

There seem to me to be two fundamentally different types of movement on slopes: what one may call the normal erosion by rain-wash and soil-creep, and the abnormal interruption of the slope cycle by undercutting by lateral corrasion or over-deepening of valleys by glaciers which are "geographical accidents." I feel that these disturbances are disturbances of an orderly succession of events, in a sense unpredictable. The emphasis in geomorphological study should be on the stability of slopes and their evolution and moulding by normal processes rather than on the disturbance of stability. It must be conceded however that the latter are the more important from an engineering point of view.

Mr. W. H. WARD: Dr. Hollingworth showed some very interesting structures which were clearly associated with the neighbouring slopes. His recent paper on his work in Northamptonshire has provided us at the Building Research Station with some important data. It has enabled us to think in terms of much longer periods of time in relation to slope stability. I imagine that most of the movements have gone on slowly in the form of creep or plastic flow under stresses below the maximum strength of the clay. As he suggests, the movement no doubt originates in the comparatively weak Lias clay, where it is most highly stressed, that is in the neighbourhood of the toe of the slope. This presumably leads to larger movements and cracks in the tension zone at the top of the slope resulting in the gulls and dip and fault structures. As soon as this movement has produced open tension cracks which extend down to the Lias, the access of water renders the slope more unstable and the movement continues more rapidly. That, I gather, is the general picture of the mechanism that Dr. Hollingworth has in mind. The initiation of the creep of the clay is clearly the relief of pressure consequent on valley erosion. However, superimposed on the above picture is another process which in my view is much more important because it greatly

accelerates the softening and subsequent movement. It is due to the presence of initially closed fissures that exist throughout the entire mass of Lias clay. As soon as the slightest deformation occurs due to the relief of pressure, the individual small blocks of clay bounded by fissures, move very slightly relative to one another and produce interfacial point contacts here and there, leaving comparatively large surface areas of the blocks completely unloaded. These unloaded regions are therefore subject to serious softening in the presence of water. The whole mass of clay in the vicinity of the slope thus becomes seriously weakened and what is superficially a firm clay behaves rather like a soft plastic clay.

The small clay pebble structure is most interesting and may give some positive clues regarding the movement and the condition of the clay when the movement occurred. I imagine that the structure is associated with zones of large shear strain and possibly the clay pebbles have resulted from the tearing and rolling of sandwiches of clay separated by a series of slip planes moving rather irregularly.

The landslips near Abbotsbury, Dorset, studied by Dr. Welch are outstanding examples. The photographs of them appeared quite characteristic of topography resulting from rotational shear slips. However, Dr. Hollingworth had said that the Gault clay was silty in that area and I should prefer to see some of this material in its natural state and explore the site before committing myself. So long as the Gault clay possessed a fair degree of cohesion I doubt whether washing out would be the cause of the landslips.

It was disturbing to see that the South Wales landslip sections shown by Dr. Evans were drawn to such a distorted scale. The only satisfactory way to study landslip data is with a natural scale. All the slips shown seemed to me to be detritus slides and not mud-flows. The example I had quoted from the Moutier-Court gorge was very similar to those in the South Wales valleys. This type of slip normally occurs where there is a series of impermeable beds alternating with porous rocks, such as sandstones and limestones. Such slopes become covered with superficial weathered products derived mainly from the clay beds, and progressive softening goes on as Professor Knox stated. The only way to stabilize these superficial blankets is to drain the water from the porous beds in an orderly manner to avoid softening of the superficial material. The only places where I have seen real mud-flows in Britain were at the toe of very active rotational shear slips on the coast in winter. The mud was of the consistency of porridge.

I wish to thank Dr. Richardson for drawing my attention to the effects of the removal of vegetation on steep hillsides in New Zealand. Uncontrolled cultivation and grazing of the land, as we all know, may have devastating effects. In New Zealand I imagine that the presence of the Bush has had the effect of retarding weathering; if the Bush had not been there these steep slopes in tertiary clays would not be quite so steep to-day. Hence as soon as the Bush is removed accelerated erosion is initiated and removes the highly weathered soil and clay superficially in the form of detritus slides, shallow slips, and mud runs.

Having worked mainly in Britain, my knowledge of earthquakes is fortunately limited. The additional force which earthquakes impose on the potential slip mass is small compared with the force of gravity. Hence the slopes must be fairly near to instability for earthquakes to cause failure. The effect of an earthquake is probably equivalent to the effect of gravity forces acting on the slope which has been rotated so that it is about 5°–10° steeper, and presumably engineers should make such allowances in regions subject to frequent earthquakes.

I find that I cannot altogether understand the views of Dr. Alan Wood. If his "slope cycle" does not allow for what he calls "geographical accidents," under

which he includes all the more active forms of denudation, then the Earth's surface would be a somewhat different place from what it is.

The CHAIRMAN: At this late hour all that is required of me is to thank Mr. Ward and those who have taken part in the discussion, particularly Dr. Hollingworth and Dr. Evans for the observations they have made and the slides they have shown. It has been a most interesting afternoon and as a geographer who has approached geography from the point of view of history I have greatly benefited. What I see in future from car or train I shall appreciate much more fully as a result of what I have heard this afternoon.

THERMAL ACTIVITY IN THE EASTERN RIFT VALLEY

LIEUT. P. C. SPINK, R.N.V.R.

A YEAR'S appointment to a Naval Air Station near Nairobi in 1943 gave me an opportunity of making a study of the thermal areas of the Eastern Rift Valley in my spare time. Of necessity I was restricted in my expeditions by lack of transport. However by using a bicycle as well as other methods of transport an amazing amount of ground could be covered in a twenty-four hour off-duty period.

Fortunately the great escarpment which forms the eastern side of the Rift Valley is within fairly easy reach of Nairobi, and I soon discovered that one of the most thermally active areas lay in the Naivasha district, only 65 miles from Nairobi. The areas examined extend from lake Elmenteita in the north southwards to Eburru mountain, thence to Orgaria mountain, and from Orgaria through the Njorowa gorge to the Suswa plain. I also visited the Longonot and Suswa craters, both magnificent specimens and, according to Gregory, contemporaneous in volcanic history. A rather hurried day's visit to the Eburru district proved so interesting that I devoted a complete leave to a leisurely and detailed examination of the various lines of steam vents which cross the mountain before proceeding southwards to the west of lake Naivasha, past Orgaria mountain, and through the Njorowa gorge. The various regions must be discussed separately, though together they form a fairly complete and continuous picture of this particularly interesting section of the Eastern Rift Valley.

Ol Doinyo Buru (*Eburru mountain*)

This mountain, which rises to a height of 9365 feet, is topographically a massive spur of the Mau, which protrudes eastwards into the Rift Valley. It ends above a narrow valley or strait through which the railway now runs, but where in a former pluvial period the waters of lake Naivasha were joined to those of lake Elmenteita, continuing to lake Nakuru as one vast lake.

In September 1943 I climbed Ol Doinyo Buru (or Eburru) mountain from the Naivasha side. On arrival at the top of the plateau at about 7500 feet I was surprised to find many acres of barley, reminding me of an arable area on the Hampshire downs. There was a splendid view up the Rift Valley with

Menengai in the far distance northwards beyond lake Nakuru, while southwards Ol Longonot extended beyond lake Naivasha sparkling just below, and farther south again lay the great crater of Suswa, and all the fascinating Kedong valley. I will never forget the Rift Valley on that sunny morning, looking towards lake Elmenteita from the north slope of the mountain; scarlet *Leonotis* blazed against the green grass, and beyond there was the blue of distant mountains and the green salt waters of lake Elmenteita.

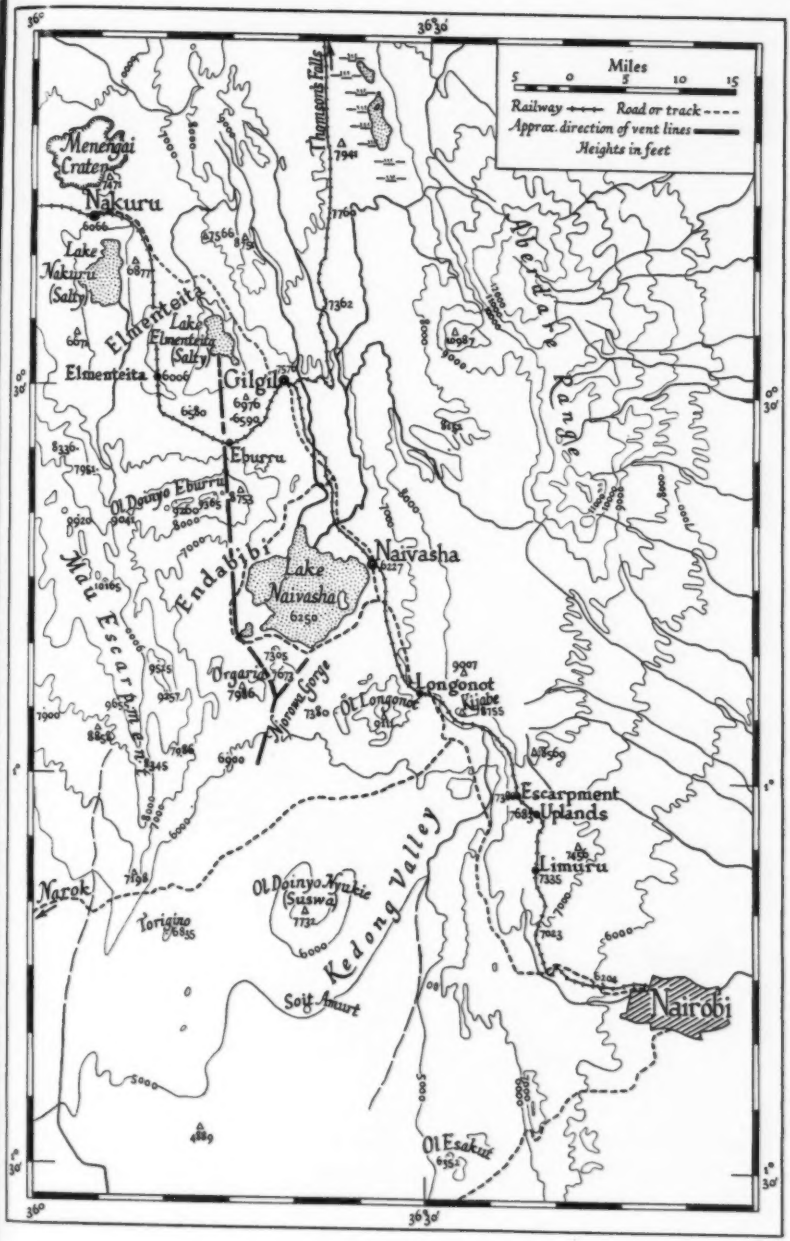
The owner of the farming land kindly lent a boy who acted as guide to the thermal area. After an hour's walk uphill to 8300 feet on the south side of the mountain, we saw steam rising from many places in a large depression with steep sides. The principal vents were covered by condensation plants producing some 1500–2000 gallons of water per day. In the absence of flowing water the local farms rely almost entirely on condensed steam for watering stock and for human consumption. Though dams do exist, and are expected to fill during a normal wet season, the only sure source of water supply is from the steam vents.

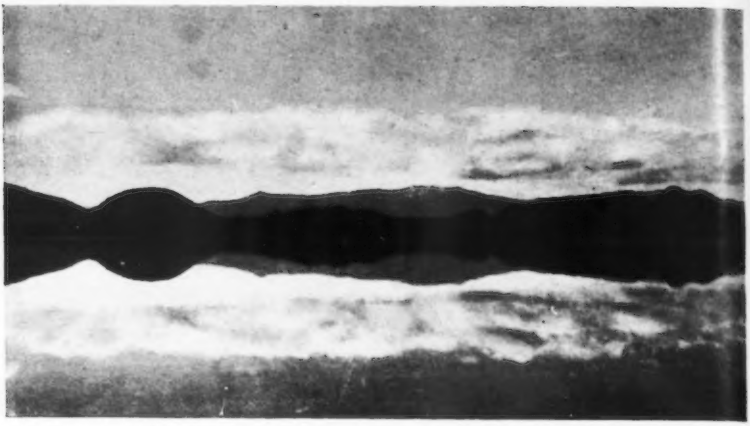
Many steam jets were under considerable pressure, and a subterranean hissing sound could be heard. The natives use the steam for cooking and potatoes were being steamed around one of the larger vents. The ground in the immediate vicinity was very hot under a cold outside crust and the air smelt strongly of sulphur, but no deposits were seen. The heat is even used for drying pyrethrum, and this economic plant, once installed, can continue indefinitely with very little expense apart from labour and maintenance costs.

It seems that a series of vents lies along a fissure which runs north and south through the mountain. Later I walked over the mountain and down the north side to Eburru railway station. I passed on the way a very deep crack which also emitted steam in places, and was obviously a part of the same north–south fissure. About a mile north of the station a continuation of the same vent line, marked by a substantial lava flow, was emitting steam at one or two points.

I hoped to find many steam vents in the vicinity of the railway station, but owing to the diurnal increase of air temperature nothing was visible. A few weeks later I visited this area at dawn when the Kisumu train dropped me at Eburru at 05.30, and this early visit brought its reward. In the dawn, which was cloudless and cool, an astonishing number of steam vents were revealed. One particularly large one was noticeable a mile up the mountain with steam rising to 100 feet or more. In all, five north–south lines of vents were visible and could be traced rising in parallel lines up the mountain. One line runs about 3 miles east of the station and high up on a spur of the mountain, and another runs 2 miles farther west. The central fissured zone lies about a quarter of a mile to the east of the station. It is about 100 yards wide in places, and very strongly marked by innumerable vents in an irregular and broken lava wall. After following the fissure for about a mile up the mountain a series of large steam vents was reached at about 7000 feet. Some pressure was noticeable, and there was also a condensation plant. From this point a fine view was obtained, and the other two lines of vents to the west were visible though these did not appear to be so vigorous as the rest.

The dawn was most impressive with the fantastic peaks and cones around lake Elmenteita purple in the ethereal light. All around steam was rising


Miles
5 0 5 10 15
Railway
Road or track
Approx. direction of vent lines
Heights in feet
Menengai Crater
Nakuru
Lake Nakuru (Salty)
Elmenteita
Lake Elmenteita (Salty)
Gilgil
Elburru
Ol Doinyo Eburru
Mau Escarpment
Endabibi
Lake Naivasha
Naivasha
Thompson Falls
Aberdare Range
Ol Doinyo Nyukie (Suswa)
Narok
Soit Amuru
Kedong Valley
Escarpment Uplands
Limuru
Nairobi
Ol Esakut
Longonot
Kijabe
Orgarie
Moroma Gorge
Torigino
36°
36° 30'
1°
1° 30'



Lake Elmenteita from the north: split Mummy crater in right foreground, Eburru mountain in background

Typical section of steam vents, Eburru mountain

Condensation plant, Eburru mountain

from the fissure lines, and to the east the steam plumes on the high spur showed white in the early sunshine. As the temperature gradually rose, the steam became less apparent until by noon only the strongest vents were visible.

It was noticeable that the ground along the fissures was covered in pumice agglomerate. The vents were emitting pure steam and no sulphurous smell was evident. There were several old extinct steam vents, but also many new ones, and some were obviously quite young and emitting from grassy surroundings. The native station-master volunteered the information that he thought activity was increasing.

Professor J. W. Gregory, in his 'Rift Valleys and geology of East Africa,' mentions only one line of these vents close to the station, and writes, "The steam vents, young craters, and still more recent faults give this locality the aspect of one of the least stable in the Rift Valley—at least, S. of Lake Baringo." [1] It would be interesting to demarcate the vigorous areas of the central fissured zone and thus keep a check on what appears to be an increasing tendency to thermal activity. In order to assess the full extent of activity investigations must be carried out at dawn, when the air temperature is low.

A few days' leave in 1944 gave me an opportunity to make a more detailed examination of the interesting thermal areas upon Eburru mountain and of the numerous steam jets and fissures.

Although the main fissure lines run north and south, small fissures appear to run at right angles to the main fissures. One farmer who has lived for some years on Eburru was able to divine steam in exactly the same way that water is divined, and he remarked upon the number of times that small steam-bearing fissures run at right angles to the main fissure. Another interesting feature of the steam-bearing fissures is that if a steam jet is disappointing in its yield of water, the deficiency can be remedied by tapping another source of supply in the same fissure without detracting from the output of the original vent. This suggests that the supply of plutonic steam must be very considerable. The increase in output by tapping makes it difficult to assess the activity by counting the steam vents at intervals, for an animal's hoof, for example, could easily increase the number of vents.

It is also reported that the visible amount of steam varies, but this might well be due to differences in air temperature and humidity during the day. An amusing experiment was to throw a tuft of burning grass, or even a lighted match or cigarette into a steam vent. Immediately the amount of visible steam increased ten-fold, due probably to the smoke particles having a hygroscopic effect and absorbing the moisture and thus increasing its visibility. Again it is said that the steam varies in its moisture content, some vents are reputed to yield a white moist steam, others a bluish dry steam; practical experience has apparently proved this contention, though it is difficult to see why steam should vary to such an extent.

Professor J. W. Gregory also mentions that he "failed to see any existing

[1] It will be noticed that Gregory refers to "recent faults." The lines of fissuring described in this paper may well be faults, but in the absence of proof of lateral displacement they have been referred to as fissures throughout. Faulting is apparent in other nearby parts of the Rift Valley, for example in the area between Magadi and Suswa.

crater on the mountain, nor is there any suggestion of a crater on the G.S.G.S. map." My leisurely examination of the mountain however revealed at least five large craters which run in a south-east–north-west line along the ridge which leads to the summit, and there are also several minor ones interspersed. Starting from the south-east, a large crater is to be found at about 8800 feet, with a diameter of a quarter of a mile and depth of about 600 feet. The floor and walls are forested, but there are bare patches which denote fumaroles and steam can be seen ascending between the trees. There is another crater, less deep, half a mile farther on which seems to have a considerable number of jets, and there is a third similar to the first about half a mile beyond the second. This crater, which is double and very large, is mainly covered in thick forest and bush; steam appears as high as the rim and also on a large bare patch lower down. Continuing through various tracts of forest and valley the middle peak of the mountain is reached at about 9000 feet, and this has a crater on the eastern side 400 feet deep; here again steam can be seen to within a few feet of the summit. This crater differs from the other three in that the northern wall is broken.

The most interesting crater of all lies to the east of the summit, and is approximately 800 feet deep and 1800 feet in diameter; its northern wall has also collapsed. This crater has a flat and fairly open floor above which on the east side rises a columnar lava wall with many plumes of steam. Considering the heat and dryness of the day this appeared to be one of the most thermally active craters I have seen in the Rift Valley, and the amount of steam visible far exceeded that of Longonot under similar conditions.

From this crater a deep fissure extends northwards and down the mountain. There are a surprising number of fissures on the north side of the mountain. While the main lines run north–south a number of lesser lines run east–west and some of the hillocks are much traversed by deep gullies. The amount of fissuring is so great on certain hills that one is led to suspect an upwelling of the lava which has eventually burst like a bubble with resulting cracks, often at right angles to each other. Holes in the lava, which are presumably extinct vents, now show signs of calcination, suggesting very great heat.

Mention should be made of a curious phenomenon which occurs on the south-east side of the mountain. Just off the road to Naivasha before it meets the lake road, and at a height of 6800 feet, there is a small fissure which draws air in during the night and expels it during the day. When examined at about 09.30 in the morning air was being gently drawn in, later at 11.00 hours it was being expelled with enough force to blow grass about quite violently. At 11.00 hours the shade temperature was 80° F., yet the temperature of the air being expelled from the fissure was as low as 59° F. It is reported that the force of the air being expelled varies considerably, and this perhaps depends on the direction and strength of the wind blowing into another crack, causing the pressure.

Lake Elmenteita and the Bad Lands

Looking north from Eburru mountain there is a rather striking tract of country from the railway to lake Elmenteita. At a first glance it appears to be comparatively flat except for several cones, but in reality it is extremely rough

country reminiscent of the central cone on Suswa or the floor of Longonot. On the eastern side there is a continuation of the main fissure lines which cross the mountain, and along which, incidentally, I traced a continuation of the steam vents some distance to the north side of the railway. These vents seemed to disappear after a mile or so and apparently none exist in the neighbourhood of lake Elmenteita.

A striking looking crater with a wide north–south split running through the centre, and suggestions of similar splits on both sides, lies just to the south of the lake and for lack of a local name is known as the Mummy or Tutankhamen. I reached this strange looking crater by crossing the railway and skirting the foot of one of the main fissure lines. A narrow grass track which lies between the fissure and the "bad lands" makes this journey fairly easy, and this was fortunate, since the bad lands have earned their name. The whole area is a mass of new and jagged black pumice lava which is now covered chiefly by an African fleabane called ol-leshwa (*Tarchonanthus camphoratus*), Candelabra Trees (*Euphorbia candelabrum*) and cedar. The latter tree seems to be a pioneer on new lava and is found growing thickly on rough lava of similar age in other places.

Two small cones were visited *en route*; one which lies a mile to the south of Eburru station rises to 350 feet and is almost perfectly conical. Its diameter is about 500 feet and the depth of the crater 180 feet as determined by aneroid. From the summit a splendid view is obtained of the fissure lines extending up Eburru mountain. To reach the second cone I had to cross a short section of the rough country, to the accompaniment of a chorus of barking baboons which accentuated the loneliness of the district. This cone rises 300 feet to 6600 feet with a broken crater about 200 feet deep on the western side.

The Mummy crater, visited from the lake end, was found to be split across from north to south by a wide cleft. From the summit, which is approximately 600 feet above the lake-level, there is a vertical wall on the north-western side. The centre of the crater is some 1200–1500 feet in diameter; it is flat and covered with grass. The floor is about 6200 feet above sea-level and the gaps through the north and south rims are 100–150 feet above the floor-level. From the southern end of the split several craters can be seen in the bad lands from which much of the lava must have welled to form that country.

The level of lake Elmenteita had fallen to a record low level at the time of my visit; local residents remarked that they had never seen so little water and attributed this not only to the long and persistent drought but also to a diversion of one of the streams which feed it. The lake is still fed by hot and cold springs. High up and some distance to the east a splendid clear hot spring, with a temperature of 104° F., which supplies water to the neighbouring farm land, eventually discharges into the southern end of the lake. Near the south-west shore of the lake there is a group of six hot springs which discharge constantly; their temperatures range from 95° F. to 109° F. There are other springs which discharge into the lake. In spite of the receding waters the flamingo population optimistically remained crowded in the available water. The bird population is interesting, and besides the flamingo there are waders, ducks, cranes, herons, the rare *Recurvirostra avosetta*, and marabou storks, to name a few of the many varieties. The marabou storks supplied a comic touch

to the scene for they resemble old gentlemen in frock coats and stood about in sad pensive groups on the dry lake floor, contemplating the dreary white expanse about them.

The southwards continuation of the Eburru north–south fault

Shortly after my visit to Eburru I learned, through a chance conversation, that further thermal activity is to be found due south of the mountain to the south-west of lake Naivasha. I decided to investigate if this was a continuation of the Eburru north–south fissure lines.

The first scene of activity visited consisted of a circular mound of very broken reddish coloured lava, some 30 feet high and about 60 feet in diameter, lying in a flat area which may formerly have been a swamp. Small amounts of steam were issuing from one side and there was a condensation plant on the top of the mound. But the amount of steam was small and it was not under pressure. Along a nearby ridge runs a series of ventholes, but there was little activity.

Continuing uphill in a south-westerly direction for 3 or 4 miles I reached a well-marked area of activity on the north-east side of the rather imposing Orgaria mountain at approximately 6900 feet. There were many steam vents and the smell of sulphur from them was very pronounced. The active area was some 300 yards long; after an interval of about a quarter of a mile of scrub there is another but less active area. Masses of scoria were piled up in all sorts of fantastic and tortuous shapes. From these steam was emitting, in some places under pressure. The ground was very hot and upon kicking away lumps of scoria sulphur deposits could be seen. These were of no quantity however except in one or two isolated places. Many chemical deposits of varying colours could be seen around the fumaroles. On Eburru the vent lines are usually along raised lava ridges, but on Orgaria they are in shallow depressions interspersed with mounds at intervals.

It was interesting to note that this active vent area runs approximately north–south. While I was investigating it very heavy rain set in which accentuated the amount of steam and enabled me to assess the full extent of the active areas. The vent line was soon shrouded in steam, and it was remarkable how many other active areas were revealed. At least four, if not five, distinct north–south vent lines could be traced running both to the south as well as to the north of Orgaria. In one distant gorge to the south-east very vigorous clouds of steam were rising, and this gorge might well merit separate investigation.

On the homeward journey late that evening, from as far away as the Naivasha–Nairobi road, steam could be seen gleaming white in the setting sun in the vicinity of Orgaria mountain, a proof, thanks to the rain, of the very live and active thermal condition of that section of the Rift Valley.

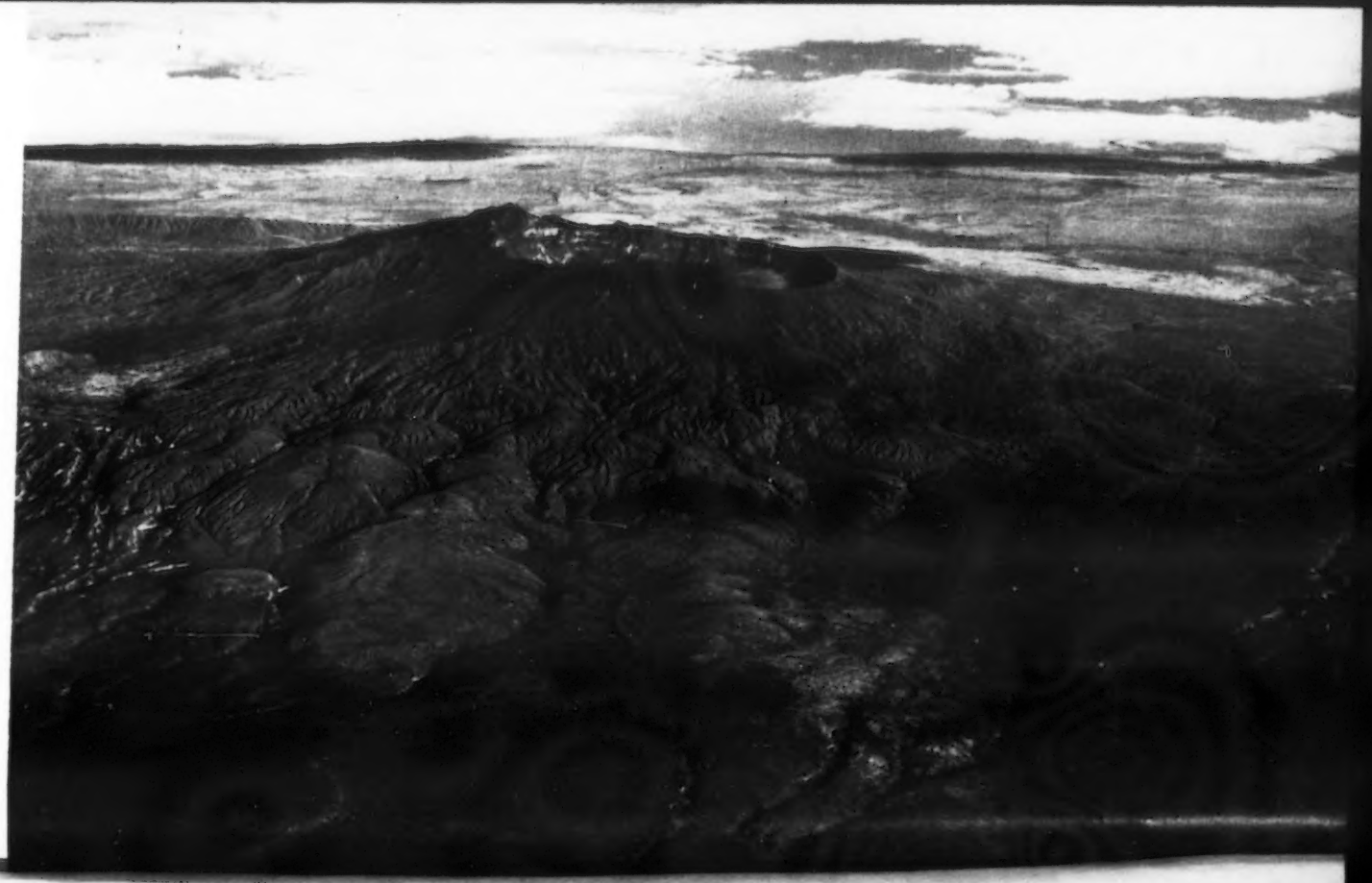
The Njorowa gorge

During the Pleistocene period when East Africa had a copious rainfall, the glaciers of Mounts Kenya and Kilimanjaro reached several thousands of feet below their present extent, and the levels of the lakes in the Rift Valley were considerably higher. Lake Naivasha, which was at that period joined to lake Elmenteita and lake Nakuru as one continuous sheet of water, had a level

Fischer's Tower, Njorowa gorge

Phot. R.N.A.S.

North-east side of Suswa crater. The white patch below cedar forest on right marks fumaroles. Old lava flows in foreground: among these are numerous steam vents



Longonot crater from the south

150 feet above that of to-day. It also had an overflow at the southern end which cut a deep gorge and finally flowed out into the area formerly covered by lake Suess.

The lake level has fallen, but the Njorowa gorge remains as one of the most interesting parts of the Rift Valley, both geologically and scenically. At the eastern entrance stands a lava pinnacle known as Fischer's Tower; on each side there are high cliffs of columnar lava between which lies a broad expanse of grass which is comparatively level and slopes gradually towards the south. After 4 or 5 miles the gradual slope ends abruptly, at an altitude of 6300 feet, above the head of a deep gorge. Nearby stands a second lava column, some 150 feet high and more cylindrical in shape than Fischer's Tower. This is known to the Masai as El Barta (The Horse).

The further descent was made between ever narrowing cliffs into a defile. Down this defile runs a very small stream which leaves a sodic deposit along its edges. After a couple of miles the gorge becomes somewhat wider and the cliffs higher. The latter are multi-coloured and are composed of clays and other stratified deposits and lavas. The predominating colour is a beautiful red, supplemented by russets, greys, and blues in many delicate shades.

A smell of sulphur soon became evident and upon rounding a bend a powerful steam vent was both seen and heard under the cliffs on the western side. The height at this point was approximately 5800 feet. This vent was under considerable pressure and made a noise not unlike a railway engine with steam up. Close by were two small pools of brownish boiling water and round the vent was a light deposit of sulphur. The ground was very hot and in the immediate neighbourhood were other steam vents, but not under pressure. This is the most powerful steam vent I have seen in the Eastern Rift Valley, the pressure being sufficient to blow away any sand or earth put over the opening. Farther down the gorge there were steam vents on both sides, in some cases exhaling from caves in the perpendicular cliff walls 300 or 400 feet above the floor of the gorge. It would be interesting to camp in the gorge and see the full extent of steam vents in the cold air of dawn.

After continuing for another mile or so the southern entrance is seen, beyond which lies the Suswa plain in the Kedong valley, with Torigino dead ahead, and Suswa a few degrees to the east. The southern entrance to the gorge is most impressive, for the cliffs rise in places to 1000 feet and their slopes, colours, and stratification are magnificent. There is yet a third pillar half a mile below the powerful steam vent. This rises to a height of 250 feet, and has a very massive base, but its general appearance is dwarfed by the high cliffs in the background.

It appears that the steam vents in the Njorowa gorge are on a continuation of the same vent lines which run north–south from Eburru down the western side of lake Naivasha and from there through the gorge and out on to the Suswa plain and possibly through Suswa itself, where steam vents are to be found, continuing south to the Magadi area which is also thermally active.

The steam vents of Ol Longonot

The Longonot crater is considered to be the most perfectly preserved of the many extinct volcanic craters in East Africa. Ol Longonot mountain rises to

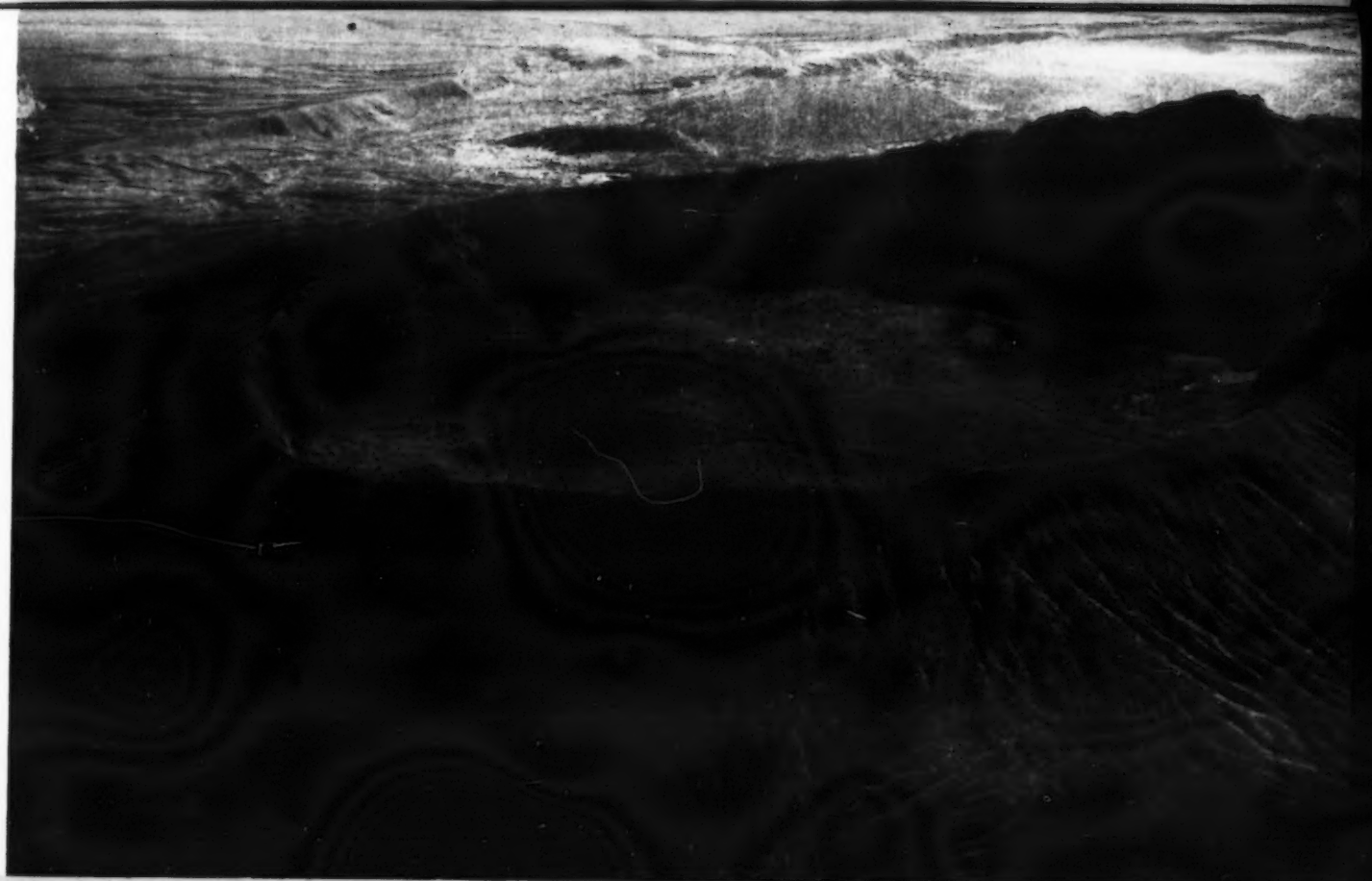
an altitude of 9111 feet at the peak, from which there is a vertical fall of some 1100 feet into the crater. The crater itself is almost perfectly circular with a level bottom over a mile in diameter, and lies directly under the eastern side of the peak. The lip, or rim, of the crater is a remarkable feature of the mountain, for it is extremely narrow with an almost vertical fall on the inside into the crater. It is possible by walking along this narrow ridge to walk round the crater and to climb up to the peak at one and the same time. At the lowest point of the rim the pocket aneroid registered 8400 feet and on the crater floor 8000 feet.

A few months previously during fine weather I visited the mountain alone and climbed up and round the crater, a matter of five fairly strenuous hours with a short rest on the summit. From the summit one sees a very fine panorama of this section of the Rift Valley, running approximately north and south. To the south-south-west lies the great crater of Suswa, to the north lies the fresh-water lake Naivasha, beyond which could be discerned the southern wall of the Menengai crater, one of the largest in East Africa. To the east lies the majestic Aberdare range. From the very narrow summit there is a more gradual fall on the west side down which immense masses of lava must at one time have flowed. The mountain is deeply furrowed on all sides with steep valleys covered in grass, small bushes, and thorn trees. I saw no sign of steam vents on this first visit.

To a large extent Longonot mountain consists of black crystalline lava from an upper Pleistocene eruption (see 'Rift Valleys and geology of East Africa,' J. W. Gregory, 1921). Immense amounts of volcanic ash have hardened into a soft rock, which is the home of hundreds of birds very much akin to the European sandmartin. The summit consists of cliffs of this soft tuff superimposed upon hard lava.

Soon after this first visit I learned from a friend who had reached the crater floor that the rocks there were hot, and that one active steam jet could be seen. Gregory notes that the explorer Hobley noticed a dozen active steam vents in 1905. About three months after my visit a second one was arranged and on this occasion, besides myself, the party consisted of P. Bally, the botanist of the Coryndon Museum, Nairobi, and the climatologist, W. G. Kendrew. The objective was to reach the crater floor and see if any steam vents were still active.

When we reached the lowest point of the crater rim, a general survey was made to decide where to descend. There appeared to be only one place on the south-east side, where a small landslide had joined the floor to the steep slope, at a possible angle for descending. No sign of steam was then apparent. However, a thunderstorm, which had been approaching from the Aberdares, broke upon us, rain continued for two hours, and the temperature fell some 10° to just below 50°. We sheltered on the side away from the crater, until the rain abated somewhat. Upon reaching the rim again we were astonished to see many steam jets in action, some with steam issuing obviously under pressure. More than thirty vents were counted, many concentrated on the east side of the crater, emanating from the almost vertical sides, others were located where the sides joined the crater floor, others were high up, two in particular were issuing from points above fissures in the cliffs about 1000 feet above the crater floor.



Longonot crater from the north. The descent into the crater was made down the wall on the south-east section

Phot. A. H. Q. E. A.

Phot. R.N.A.S.

Suswa caldera from the west, showing the widest part of the moat. The long ridge in the middle distance marks the outer rim

We descended 400 feet into the crater by making a steep traverse down and across the south-east side which had a slope of about 65 degrees. On the way down we passed two steam vents hidden from our survey on the rim; these consisted of fissures in the rock slope and the steam was not under any great pressure. The rocks were very hot and a hand could not be held in the vent holes without the risk of scalding. Vegetation was growing all around, and the steam did not appear to have any particular odour and seemed to consist of fresh water. I had an uncomfortable experience soon afterwards, for the hot ground suddenly slipped under my feet and I found myself in a precarious position hugging as best I could to the hot rocks and unstable wet earth; below me was a vertical drop of 100 feet into the lava floor of the crater. Fortunately Bally saw my danger and by hanging on to a tree just above and extending his leg, enabled me to pull myself up.

The crater bottom consisted of large jagged pieces of lava, with a tangled profusion of bushes, shrubs and stunted trees growing out of the cracks; there was no sign of grasses or humus of any kind. This jungle was almost impenetrable by reason of its thickness and the very uneven lava floor which appeared to consist of a succession of terraces.

By the time the rim was regained the storm had passed and a warm sun was shining upon the mountain. Most of the steam vents were no longer visible with the exception of those under pressure and a few in the cool shadow of the western side. We could only conclude that the sudden fall in temperature due to the storm, together with the rain, had both increased the amount of steam and made its condensation more apparent than would be the case on a warm dry day. Nevertheless, the rocks are always hot and water vapour must be continuously emitted even if invisible because of a high air temperature.

Finally the party climbed the crater rim to the summit in a clockwise direction, and during the ascent on the north-west side very strong smells of sulphur were noticed in two or three places, wafted up by the prevailing south-easterly breeze.

The Suswa crater

Few people in Kenya realize that Suswa is one of the most interesting volcanoes in the Rift Valley, or that its extent is even greater than the more accessible and therefore better known Menengai crater which lies just to the north of Nakuru. The diameter from the peak of Suswa to the outside rim of the caldera is estimated in one place to be as much as 10 miles. Suswa (7732 feet) is known to the Masai as Ol Doinyo Nyuki (The Red Mountain). The crater lies well out in the floor of the Rift Valley, and is some 19 miles south-south-west of Longonot.

The main characteristic of Suswa is a huge central plateau formed of comparatively new lava and covered by a cedâr forest. The area is estimated to be about 4 square miles, and tilts from south to north. The sides of the plateau are steep and the whole is surrounded by a deep ditch or moat of an average depth of 500 feet. The mountain area was flown over a few days prior to the expedition in order to photograph the salient points. The plane was able to fly down in between the walls of the moat, which looked extremely dry and barren. Even the cedar forest, which from a distance had looked green and

pleasant, upon close aerial examination proved to be very patchy and a high proportion of the trees seemed to be dead. Moreover, there was no sign of a pleasant humus-covered floor, the trees appeared to be growing from fissures and cracks in the lava.

This central plateau was named the Lost Land by W. C. McGregor Ross many years ago owing to its inaccessibility. I decided, in October 1943, to visit and examine this unique area. A four-day safari was necessary, and, since the area is virtually waterless, we had to carry all the water supplies for our party, which consisted of P. Bally, J. Richard, the geologist, and myself.

The approach was made from the Kedong valley on the east-south-east side of the mountain. After a gradual ascent we came to a Masai kraal on the outskirts of the caldera, from the chief of whom we tried to obtain information concerning water supplies. But he would volunteer none, and there was no reason why they should divulge the location of their very meagre supply to white men.

After crossing the caldera we sited our camp about 200 yards from the edge of the moat on the south-south-east side, opposite the highest part of the plateau. Early the next day we started for our objective. The aneroid showed an altitude of 6250 feet prior to the descent. After making our way down through very thick and thorny vegetation, which included predominantly the prickly *Euphorbia Ballyi*, aloes, the sharp and agonizing Sansevieria, the Kedong Palm (*Dracaena sp.*), and giant nettle, and over enormous bare lava rocks, we reached the bottom, over a 500-foot descent. Then began an ascent of about 800 feet to the highest point of 6500 feet reached on the plateau. After a final scramble over bare volcanic rocks a line of fumaroles was reached running just under the rim of the plateau, indeed it was subsequently noticed that fumaroles appeared intermittently along the rim around almost the whole of the east, north-east, and northern sides. It is probable they also extended around the cone and along the sides which were not examined. Deposits of sodium sulphate and a sprinkling of sulphur were seen among the fumaroles which registered temperatures between 80°–90° C. (approximately 180°–190° F.).

Lack of water was one of the main troubles of this safari. We had hoped to condense some steam from one particularly powerful steam vent which lay on the south-south-east side of the crater near our camping site, but the corrugated iron sheet we brought proved inadequate. It would be an inestimable advantage both to the Masai inhabitants and to explorers of the region if an efficient condensing plant of the same pattern as those used on Eburru mountain could be installed at that particular steam vent, which is powerful enough to contribute many hundreds of gallons daily. Many other vents were to be seen at dawn in the vicinity of this vent, mainly appearing from old lava flows which rim the inside edge of the crater. The cool air also revealed various other fumaroles at the bottom of the moat, and a particularly active small cone just below the mountain summit on the south-south-west side.

After moving camp round to a point above the northern rim of the moat it was observed that a rough track descended to the bottom and meandered along and below the lowest part of the plateau. Since baboons also frequent this side of the mountain it was thought that there must lie the meagre water

supplies so important to the Masai. Subsequent enquiries confirmed this assumption.

The ascent to the summit was pleasant enough, preceded by an army of baboons for the first part, and after making a large detour caused by the remains of the wall of the original crater which lies to the north of the peak, and into which there is a sheer drop of about 1000 feet, we reached the survey beacon. From there a good general idea could be formed of the geography of the mountain. The great cedar-covered plateau was the dominant feature, in places on its surface could be seen raised knolls which are no doubt the remains of the various craters from which much of the lava once erupted. Beyond extended the great caldera we had crossed from the south-east. We could see Longonot to the north-north-east, the Ngong hills far to the south-east, and even as far south as some of the volcanic cones beyond lake Magadi.

THE NEW EDITION OF THE ONE-INCH MAP

ORDNANCE SURVEY. NEW POPULAR EDITION ONE-INCH MAP of England and Wales. London N.W., Sheet 160. Southend-on-Sea, Sheet 162. 25×28 *inches. Mounted folded 3s, paper flat 2s each sheet*

THESE are the first two sheets to be published of the new Sixth Edition of the One-Inch Ordnance Survey Map. For this the plates of the Fifth Edition, with revisions, have been used where already published. Other sheets will be in this style, the only change being that the contours are now in orange, from the same plate as the class 2 roads. There is incidentally a discrepancy between the information on the sheets and on the covers regarding the date of revision. The sheet bears the legend "Full revision 1930 with later corrections"; on the cover the date appears as 1938. The principal interest of this edition is that it shows the new metric National Grid.

The sheet lines have been re-arranged to include larger areas, giving in most cases considerable overlap, and to coincide with grid lines. All sheets will be of a standard size, 24·8×27·9 inches, and when complete this new series will cover England and Wales in 115 sheets (numbered from 64 to 190 with some omissions), a considerable reduction from the 146 sheets of the Popular (Fourth) Edition. Contours are strengthened at each 250 feet; woods in pale green, without a tree symbol; water in light blue. The class 1 roads in red tend to dominate the map, railways being relatively inconspicuous, particularly in built-up areas. The portion of the London area on sheet 160 is perhaps the least satisfactory, some names for instance are rather obscured, but on the scale this is unavoidable. As a whole, the general appearance is clean and fresh. The ingenious new folding makes it possible to consult any section of the map without unfolding the whole.

Within the outer border there is a generous margin, used mainly to indicate the continuation and destination of roads. The width of this leaves little room at the foot, where much information has had to be crowded: characteristic signs, scales, and explanation of grid references. Space might have been found to name the projection; on the Fifth Edition it was stated to be the Transverse Mercator with origin 49° N., 2° W. The intersections of the graticule are shown where they do not obscure detail, and the outer border is divided for latitude

and longitude. It is strange that the sheets do not bear titles or sheet numbers, though these appear on the covers; the numbers can only be ascertained from the small diagrams indicating the numbers of adjoining sheets.

As this edition shows for the first time on this scale the new metric National Grid, a brief summary of the method of reference and some observations which it suggests may be of interest. An explanation is printed on the inside of the covers, and an example is given at the foot of each sheet. The 10-kilometre grid lines on the face of the map are solid black, the 1-kilometre fine black dots. The grid lines are numbered in the margins, the 100-kilometre digits drawn smaller than the others, and no figures appear on the face of the map. The grid is therefore not too prominent to detract from the appearance of the sheets, and in general is easy to refer to. In built-up areas however the grid, particularly the 1-kilometre lines, tend to disappear completely: if the points at which they meet the margin were ticked, it would assist in picking them out.

The grid is constructed on the central meridian of the projection, to which the other north and south grid lines are parallel; consequently, except on this meridian, grid north does not coincide with true north. Each map therefore has a statement of the relation of true north to grid north for the centre of the sheet, but no statement of the change over the sheet is given. For convenience of numbering, the origin of the grid references is not that of the projection, but has been transferred to a point 400 kilometres to the west and 100 kilometres to the north.

The explanation of the National Grid is necessarily brief and somewhat oversimplified. Four grid references are described. The "Normal National Grid Reference," for defining a point to the nearest 100 metres, gives the easting and northing from the south-west corner of the particular 100-kilometre square. This reference for St. Paul's Cathedral, for example, is 320811. To render this reference unique, that is, to relate it to the transferred origin, the instructions are to specify the particular 100-kilometre square "by quoting the number of hundreds of kilometres of the Eastings and Northings of the south-west corner of the square." Since the easting of the south-west corner of the square in the above example is 500 kilometres and the northing is 100 kilometres, the reference to this square is 51, and the Full National Grid Reference is 51/320811. The other two forms of reference specified are the "Four Figure" and the "Full Four Figure," giving references to the nearest kilometre; for the above example they are 3281 and 51/3281.

The two smaller figures in the reference of the south-west corner of a sheet give the square number, for a portion at least, of the sheet. They are therefore important, and it is not clear why they should be less emphasized than the remaining figures. The diagram showing the 100-kilometre squares, which is given at the foot of the map, gives little help in determining the square numbers, which must be read from the map; it might therefore be omitted.

It will be observed that, if the easting and northing from the transferred origin were quoted in hundreds of metres, the Full National Grid Reference would take the form 53201811, which is no longer and appears more logical than the form adopted. However the difficulty would then arise that a "normal" reference to the nearest 100 metres (six figures), in this case, 320811, could not be distinguished from a "Full Four Figure" reference (to the nearest kilometre), which on this method would also consist of six figures, 532181.

It is difficult therefore to see how the "square numbers" can be avoided, though this system appears to have disadvantages. These numbers are liable to be confused with the sheet numbers, based on sheet lines which have no common relation to the 100-kilometre grid lines. The North-West London

sheet, for example, falls on portions of four 100-kilometre squares. Since a Normal National Grid Reference will be taken from a particular sheet, there may also well be a tendency to quote the sheet number in conjunction with it, which would cause confusion, the more so where the sheet number consisted of two figures only. G. R. CRONE

ANOTHER MONUMENT OF EARLY DUTCH CARTOGRAPHY

LA MAPPEMONDE DE PETRUS PLANCIUS gravée par Josua van den Ende, 1604. By MARCEL DESTOMBES. (Publications de la Société de Géographie de Hanoi.) *Hanoi: Imprimerie d'Extrême Orient*, 1944. 15½×12 *inches; 6+54 pages; folding maps. Subscription price* $28 (*with duplicate for mounting* $38)

A NEW discovery, from the most notable period of Dutch cartographical work, is a hitherto undescribed version of the Plancius world map of 1592, dating from about 1604. M. Marcel Destombes, who found this in the Bibliothèque Nationale, is already known for his studies of early maps, some of which have been recorded in this *Journal*.

M. Destombes is a competent expositor of the map of 1604, and his monograph is both complete and well arranged. After a full description of the map, from the successive standpoints of its geometrical basis, its hydrographical, geographical, and decorative content, he discusses its authorship and sources, and gives his conclusions, which for the most part are convincing. Some, as he admits himself, are rather venturesome, but they are always suggestive and a good many little-known facts are recorded incidentally.

The map resembles so closely, both in its general character and detail, the large map of Plancius preserved at Valencia, now so well known to students through the researches of Dr. F. C. Wieder, that M. Destombes is justified in regarding it as a second edition of this, though it seems that Plancius himself had no hand in its production. In the sheets that have come down to us neither author's nor publisher's name is recorded, but its engraver appears as Josua van den Ende, much of whose work in this field is already known, while M. Destombes sees reason also to ascribe to him various unsigned specimens. The unusually fresh condition of the newly-found version adds greatly to its value, giving a clue to many indistinct legends in the Valencia original. Although the plates were newly engraved, the projection used (the *plate carrée* or simple cylindrical), the size, the elaborate border, and geographical details are closely copied from the 1592 version.

The comparative contents of the two editions are well brought out in an outline map in black, on which the main modifications found in the later version are over-printed in red.

In the northern hemisphere the differences between the two issues are confined to one or two additions in the regions of Davis Strait and Novaya Zemlya, showing English and Dutch discoveries since 1592; and in Guiana, where details based on Raleigh's voyages are shown. In the southern hemisphere the differences are more extensive, consisting chiefly: in the revision of the coastlines of South Africa, South America, and Magellanica; in the much more elaborate decorative effort; and in the insertion along the lower border of eight

small maps in cartouches, representing features (principally important straits) lately visited by Dutch voyagers. To make room for these some of Plancius's wind-roses, etc., have been omitted, but the latter's special map of northern Europe has been retained, and somewhat extended towards the east. Plancius's northern and southern hemisphere maps have also been copied, with the addition of the respective portions of the ecliptic and signs of the zodiac.

Special attention to the modifications introduced by Van den Ende is called for, as they help to confirm the date of 1604 assigned to the map and also to indicate the probable sources drawn upon, and auspices under which it appeared.

The principal sources of both editions are examined in detail. Those of the first had already been dealt with by Dr. Wieder, and M. Destombes accepts most of his conclusions. While Mercator's great map of 1569 was the main basis, Portuguese sources in MS. supplied most of the hydrographical details. But Wieder's idea that a series of charts by Bartolomeo Laso had been the main authority for these details is rejected, and good reason is shown for believing that an anonymous world-map preserved at the Dépôt de la Marine, still imperfectly known, must have been the actual basis for most of the coast-lines apart from Europe. M. Destombes shows pretty conclusively that this map was the work of Pedro de Lemos, nephew of Luiz Teixeira, who became head of the Spanish Hydrographical Office in 1596; and he gives for the first time a complete photographic reproduction of this map, which is a valuable addition to the present monograph. The general style seems closely similar to that of an early Portuguese MS. map, on vellum, owned by the Society, and it is possible that this was by the same maker. But as it is not accessible at present, the suggestion cannot be tested.

The author reviews the principal voyages made in the interval 1592–1604, just the period when the Dutch and English were coming forward as pioneers in distant enterprise; while the voyage of Sarmiento to the Strait of Magellan has also to be considered, M. Destombes finds that nearly all the principal modifications in the second edition could be obtained from printed documents, including the now-lost Hondius globe of 1597, for we have some clue to the geography of this in the accompanying text written by its maker. Some of this was taken from the MS. world-map of the Spanish cartographer Luiz Teixeira, but this last was not used by Van den Ende, who however agrees with Hondius where the latter drew upon printed material, such as De Bry and the series of narratives issued by the Amsterdam publisher Claesz; these latter were the principal sources of the eight map-cartouches along the lower margin of the main map. As regards Sarmiento this map is of special interest as it avoids the serious error in longitude made both by Plancius (1592) and in maps by Claesz and his copyist Van Langren.[1]

In the sections dealing with the decoration of the map great care has been taken in tracing the illustrations, so far as possible, to their printed sources. It would be out of place here to discuss them in detail, but mention must be made of the two larger compositions, which seem to be the original work of Van den Ende. The two figures in one of these, seated in a barge under a canopy, may represent Elizabeth and Drake, but more probably Spanish personages. Still more interesting is a group of persons clustered round a large globe, of the same general character as a corresponding one in the original map of 1592. Both versions are held to represent a meeting of Amsterdam geographers to whom Plancius is discoursing. This central figure seems to agree in feature with one

[1] As an instance of M. Destombes' thoroughness it may be noted that Sarmiento's pleasantry in regard to the "Painter's Wife's Island" when questioned by Drake about it (see *G.J.* 48 (1916) 275) has not escaped him.

engraved a good deal later by W. Delff, and other figures too may be based on actual portraits: M. Destombes makes alternative suggestions as to the persons they represent. A detail of special interest is the representation of certain instruments of survey such as were recommended by Plancius.

It remains to speak of the probable publisher of the map and the place to be given to its engraver among Dutch map-makers of the time. His claim to have been the publisher is at once justly dismissed. Plancius is excluded because, when bringing out his map of 1607, he speaks of his earlier one without hinting that he had done anything to revise it, while stating that it had been copied by others. The want of agreement with contemporary work of Claesz and Hondius is held to rule these out, rather summarily perhaps, as instances might be cited of neglect of good material, once used, in later work of the same map-makers. There remains only Blaeu, just beginning, in 1604, his long career as a publisher of fine maps; and the fact that many of these are actually signed by Van den Ende as engraver lends weight to the view that Blaeu deserves the credit as publisher of the lately-found specimen.

If M. Destombes is right in ascribing to Van den Ende various publications by Blaeu not signed by any engraver, the whole series of signed and unsigned as listed in an appendix makes an imposing show. One important item included is the world-map usually ascribed to Hoeius from its re-issue much later by H. Allardt, with Hoeius named as author in place of another evidently erased. In one copy the original publisher's name has been read as Janssonius (*i.e.* Blaeu), so we seem to have another early example of the collaboration of engraver and map-maker.

Wieder had suggested that one of the noted artists, Saenredam, was the possible author of three of the works now assigned to Van den Ende, but M. Destombes points out that the younger Saenredam, whom Wieder apparently had in mind, was a boy when the pieces in question were engraved. It may be noted however that the father was certainly interested in map-making, being himself responsible for one of Holland, dated 1589, reproduced some years ago by C. P. Burger in 'Het Boek.' The probability that professional artists were called in to help in the decoration of the fine Dutch specimens seems to call for further inquiry, though it is dismissed by M. Destombes as unlikely.

There are many other points of interest, including a reference to a copy of a map engraved by Hondius to illustrate Drake's voyage, signed and dated 1586, preserved at the Service Hydrographique de la Marine at Paris. It does not show Cavendish's route, as does the rare map so often reproduced, of which it would seem to be a first undescribed edition. As however M. Destombes says that it had possibly been preceded by others on a larger scale, it may have been smaller than the known version with the routes of the two circumnavigators. The question needs clearing up. It should also be noted that Wieder's belief that an edition of the Plancius map of 1592 was brought out in England in 1595 is not accepted by the present author, who thinks that the issue referred to by Linton in 1603 was merely the original with an English publisher's label pasted on.

The value of M. Destombes work is enhanced by an appendix reproducing all the legends of the map, both in the original Latin and in a French translation. Both transcript and translation seem to have been for the most part carefully done, though an occasional mistake may be noticed. Thus in one version of the legend about the Great Wall of China (that on the Northern Hemisphere-map) the word *crepidines* (blocks) is curiously enough misread *crepitudines* (creakings) and is translated "crests." That the word was used somewhat in the sense of the modern "massifs" is shown by the actual representation of the wall (as in the

map printed by Ortelius in 1584), as closing the gaps between (*inter* not *per* as it is read in the printed text) the mountain ranges, and not as following their summits.

It is unfortunate that the title of the map, which probably recorded the date and the publisher's name, as in the original of 1592, has been lost, and also that the reproductions include only the map proper, without the broad band with allegorical figures representing the four continents, which should appear below the base of the map. It would be interesting to compare these figures with those shown by Hondius in his big map of 1608 now owned by the Society, which they seem to anticipate by some four years. We may also regret that war conditions have made it necessary to reduce the scale of the reproduction to one-half, making much of the smaller detail almost illegible.

M. Destombes' monograph deserves careful study by all interested in early maps. It will be found useful, in fact, as a summary of the chief Dutch work of the period in this field, and of the nautical enterprise on which it was based, as well as the published literature. The very complete references to authorities are another valuable feature. Lastly a word of praise is due to the enterprise shown by the Hanoi Geographical Society in undertaking so serious a task in war time, and to the excellent printing. E. HEAWOOD

REVIEWS

ASIA

THE MAKING OF MODERN CHINA: a short history. By OWEN and ELEANOR LATTIMORE. *New York: W. W. Norton*, 1944. 8×5½ *inches;* 212 *pages; sketch-maps.* 15*s* ($2.50)

As is implied in the title, Mr. and Mrs. Lattimore are primarily concerned with contemporary China. A historical sketch of the imperial period occupies the first half of the book, the history of events subsequent to the revolution of 1911, the remainder. In the historical chapters the authors direct attention to the fundamental economic and political factors which determined the rise and fall of dynasties, and the relations between the Chinese and their nomad neighbours; they do not enter into the detail of events. The reader unfamiliar with Chinese history will therefore find their survey illuminating and instructive, and need not fear encountering a host of names.

The second part of the book, which deals with the complex history of the Chinese revolution in the last thirty years, including the war with Japan, has the authority of an expert and eyewitness of this period. Here, too, the authors have endeavoured to avoid confusing their story with details and names, and have related the conflicts of revolutionary China both to the underlying economic and political heritage of the empire, and to the pressures and strains created by contact with the West.

Finally the authors discuss the problems of the future. They do not by any means subscribe to the belief that civil war between the Communists and the Nationalist Government is inevitable. They stress the odium which public opinion would visit upon any party which initiated a civil war, and the danger which a party that openly relied upon foreign support would incur in a country where the war has roused very strong nationalist feeling. The Sino-Russian treaty and its consequences are already supporting the justice of this view.

The authors, who have travelled widely in China, bring their knowledge of the geography of the country to explain many aspects of the relation between China and the nomads in the past, and to the modern form of this problem, the future relations between China and an Outer Mongolia under Soviet influence.

C. P. F.

OSNOVY KARTOVEDENIYA. Istoricheskaya Chast. (Foundations of cartographic knowledge, historical section.) By K. A. SALISHCHEV. *Moscow: Geodesisdat (Publ. Dept. of Head Office for Geodesy and Cartography)*, 1943. 9×6 *inches;* 238 *pages; illustrations*

'Osnovy Kartovedeniya' is a book in three parts, of which this is the historical part; there is also a General Part dealing with cartography as a whole, theory and practice, and apparently another dealing with materials for maps, so answering the needs of the course in cartography given in the Institutes of Engineers in Geodesy, Air Photography, and Cartography. These are now apparently under the NKVD, the all-powerful Department of the Interior. Chapters I–III give the history of maps outside Russia: references are made to Marx and Engels for the most obvious facts, and any shortcomings put down to capitalism, but it would be quite a good account if the facsimiles were not too poor to be of any use.

Chapter IV, Maps in Russia, is interesting, and shows what a remarkable amount was accomplished in such a vast country. Besides the maps published abroad, historians will be glad to have an account of the Great Terrier (Chertezh) in the late fifteenth century, of which we have the description but not the plan, the maps of Siberia by P. Godunov (1667) and S. Remezov (1698), and of Russia by Kirillov in 1735. And so we come to the 'Atlas of the Academy of Sciences' in 1745 reaching "the general scientific level of the day." There was also the "general land survey" (*mezhevanie*) in 1765 which included some 3,000,000 square kilometres. Maps under the Tsars suffered from being concentrated on regions in which war was possible; the chief maps of really wide extent were the 100 sheet map (1 : 840,000) in 1804; next came in 1839 Schubert's 10-verst to the inch map (verst =3500 feet, 20 feet less than $\frac{2}{3}$ mile, so this is 1 : 420,000); parallel surveys on larger scales were also made (pp. 173 *seq.*). Next came a 3-verst map of Western Russia. Figs. 61 and 62 are very useful diagrams of the military maps on various larger scales existing in 1917. An account is also given of maps made by Russian authority beyond the frontiers.

Of more actuality is the account of map-making since the Revolution (pp. 196–218). A rescript of Lenin himself is quoted which initiates the tendency towards what I feel as miscellaneous and diagrammatic maps showing everything but the surface of the globe and the places on it. This certainly soon bore fruit in excellent geological maps, Europe 150-verst in 1922, and Asia 100-verst in 1925. It is to me rather a disappointing story. After the frenzied efforts called forth by the civil war, the map institutions were continually enlarged and improved, and better schemes for them to fulfil provided before they had accomplished earlier ones. At the same time the multiplication of schools created a huge demand for educational maps. That is one reason why moderately priced maps of the U.S.S.R. cannot be obtained. But meanwhile the cartographic staff had been multiplied by six since 1926, and air photography had come in to help, especially in thinly settled regions. The central institute responsible for producing this book was formed in 1929. Note should be taken of the Quaternary Map and the Soil Map, both 1/2·5M, published in 1930. Finally in 1933 it was decided to start the 'Great Soviet World Atlas,' which no doubt surpasses all others, but only the first volume is generally accessible, full of everything but what we most want, the surface of the U.S.S.R. E. H. M.

AFRICA

LA TUNISIE ORIENTALE: Sahel et Basse Steppe. Etude Géographique. By J. Despois. (Publns. Fac. des Lettres d'Alger, 2e. ser. t. 13.) *Paris (Algiers): Société d'Edition, Les Belles Lettres*, 1940. 9½ × 7½ *inches; 616 pages; illustrations and maps*

M. Despois has added to his general work on Tunisia ('La Tunisie,' Paris, 1930) a valuable and detailed study of some of the most interesting areas in the country, a work which will rank with F. Bonniard's 'La Tunisie du Nord' (Paris, 1934) as a major source of geographical material on the eastern part of French North Africa. He deals with country over which, in due course, the war swept with great speed, namely the coast a little north of Gabès to the vicinity of Enfidaville, and the hinterland to a depth of 50–75 miles. The book is to be strongly recommended to those interested in Tunisia or likely to visit it: it is an authoritative work, well written and attractively produced, founded primarily on the author's own field work and supported by comprehensive references and other footnotes.

The primary object is to examine the present conditions and means of livelihood, economic development, colonization, settling of the nomads, and the effects of each on the other. It is a complex study, to be made, as M. Despois shows, against a background of climate, soils, and water supply, history, and the means and conditions of life in the past. This is not a regional monograph, and it would be both misleading and unjust so to regard it: the author is aiming at other and more practical objectives, and attains them by academic means. By comparison with his notable achievement a regional monograph might be unimaginative and inconclusive.

In this review it is unnecessary to dwell on the physical and historical parts of the book, except to remark that M. Despois pays commendable attention to soils and gives a fascinating account of the country as it affected the ordinary man, be he Roman, Berber, or Arab. Much of this background is drawn into perspective in a chapter devoted to the change of natural conditions during historic times, a contentious subject which the author handles with admirable restraint. He concludes that the climate has remained unchanged for two thousand to two thousand five hundred years, but that the vegetation, nature of soils and of water have been able to change locally and slowly: in his opinion it is cultivation and then abandonment, far more than nomadic life, which are the essential causes of transformation. Moreover he concludes that man's creation of a "pseudo-desert" does not seem to have changed profoundly the natural conditions, and that this zone could certainly be conquered now by cultivation, as it was in the past.

The economy is based on olives, cereals, and grazing, with gardens around the towns and fishing off the coast. The olive is characteristic of the less arid districts where a combination of physical conditions, such as the incidence of dew as a source of moisture, and of human effort has resulted in the establishment both of small groves and of the extensive plantations of the Sahels of Sousse and Sfax: the latter constitute one of the chief witnesses to the colonizing energy of the French in North Africa. Cereals are grown farther inland, for local consumption not for export, and output fluctuates greatly from year to year because of the irregular rainfall. Still farther from the coast grazing, mainly of sheep and goats, is carried on in districts which not even French enthusiasm for extending the frontiers of fixed settlement seems likely to put to better or more intensive use in the future.

Economic development, pacification, and establishment of communications

have led to many changes in the life, settlements, and dwellings of the people, which M. Despois analyses at some length in the last section of his book. Market towns and ports have grown up, usually on the basis of old settlements, though a few of them are new. The old religious centre of Kairouan remains native, despite its considerable tourist traffic: so do the towns of the Sahel of Sousse like Msaken and Kalaa Kebira with almost no European inhabitants. Sousse and Sfax, in contrast, have modern European quarters of the pattern common in French colonial territories and are well-equipped ports, dealing with the export of local agricultural products, especially olive oil, and of minerals, chiefly phosphate: indeed the phosphate traffic makes Sfax the leading port of Tunisia with a greater volume of trade than that handled by Tunis. The good facilities of Sousse and Sfax and their reasonable rail and road communications with the productive areas in the interior are causing the smaller ports such as Mahdia and Monastir to stagnate and decline.

Finally the author attempts to evaluate the French achievement in this part of Tunisia. French and British colonial policy differ so fundamentally that it would be useless to compare the work of the French in Tunisia with British enterprise in, say, Nigeria or Ceylon, especially as French North Africa, even without Algeria, is, strictly speaking, not colonial territory.

The French may take just pride in many of their achievements of the last half-century in Tunisia, but a great deal remains to be done, and done quickly, if relations between them and the native population are to be improved and strengthened in the difficult years that lie ahead of the authorities in this section of the Moslem world. K. S. S., R. W. S.

OUR HOMELAND: a regional geography. Book I. South-east Gold Coast. By D. A. CHAPMAN. *Achimota: Achimota Press*, 1943. 8×5½ *inches;* vi+124 *pages; maps*

HISTOIRE ET GEOGRAPHIE DU CAMEROUN SOUS MANDAT Français. By J. BOUCHAUD. (New ed.) *Douala (pr. Grange-over-Sands)*, 1944. 9½×7 *inches;* 48 *pages; illustrations and maps*

Local studies by trained geographers are too rare in tropical Africa, and both these books will help towards elucidating West African problems, many of which have at least their basis in geography. They will probably be used mainly in African schools, and it is to be hoped that they will encourage their readers to study the local geography themselves, for only thus can many of the gaps in our knowledge of African geography be filled.

Mr. Chapman, an African graduate of the University of Oxford and now senior geography master of Achimota College, has produced the first of a series of textbooks dealing with the geography of the Gold Coast. His aim is stated in the preface: it is to study not merely the physical setting of the south-eastern corner of the Gold Coast but also the use made by man of this environment. This object is achieved in the text, though in places one may wish for greater elaboration. The maps are less successful and by themselves would give only an incomplete impression of the country's regional geography.

Father Bouchaud, a Roman Catholic missionary in the French Cameroons, deals with a much larger area than Mr. Chapman. His book, a revised and enlarged edition of an earlier school text, is much more concerned with geography than history, despite its title. Physical geography, human geography, political geography, and economic geography are the headings of four of the five parts of the book; history forms, perhaps rather surprisingly, only the last section of "human geography," in which are also included the characteristics of the many tribes of the Cameroons, the broad facts of population distribution, and brief

descriptions of the chief towns. Little attempt is made to correlate the facts of physical and human geography, and in places the book reads like the geographies of half a century ago. "Political geography," for example, consists largely of details of administrative organization and divisions and a list of the various taxes imposed. As a handbook of the Cameroons rather than as a geographical study, it is a successful compilation of a mass of material not otherwise easily accessible. The book is illustrated by numerous photographs and maps, so poorly reproduced however as to have only limited value. There are four maps printed on transparent paper beneath which base maps, one showing physical features and the other communications, can be placed, but unfortunately the scales of the transparencies and of the base maps are not identical.

Father Bouchaud's book is a source of factual material of the handbook type, whereas Mr. Chapman's work is an exposition of the modern geographical approach. R. W. S.

ECONOMIC AND HISTORICAL GEOGRAPHY

THE LETTERS OF JOHN McLOUGHLIN FROM FORT VANCOUVER to the Governor and Committee. Second Series, 1839–44. Edited by E. E. RICH. (Champlain Soc. vol. 6, and Hudson's Bay Record Soc. vol. 6.) *Toronto: (pr. Glasgow): Champlain Soc.*, 1943 (*Hudson's Bay Record Soc., London*, 1944). 10×7 *inches;* l+428 *pages; illustrations*

The first volume of John McLoughlin's letters was reviewed in the *Journal* for August 1943. The second volume consists, in the main, of McLoughlin's correspondence between 1839 and 1844, and the work will be concluded in a third volume covering the years 1844–46.

The letters of the second volume are largely concerned with the controversy which sprang up in 1841 between John McLoughlin and Sir George Simpson on the conduct of trade on the north-west coast, and the murder of McLoughlin's son. Early in 1839 an agreement was concluded between the Hudson's Bay Company and the Russian American Company concerning trade and territory on the coast. Among other provisions the Hudson's Bay Company agreed to supply the Russian American Company with various agricultural products. The working of this agreement ultimately led to the rift between John McLoughlin and Sir George Simpson and the development of their differences in policy can be followed in the letters.

This dispute was further embittered by the murder of McLoughlin's son, John McLoughlin junior, at Stikine in April 1842. The bereaved father had a grievance against Sir George Simpson on two counts, first for leaving a young man alone with hostile subordinates, and secondly for readily accepting McLoughlin's alleged drunkenness and incompetence as an excuse for the murder without a full investigation. The letters discuss the circumstances of the murder and the investigation at length. McLoughlin's repetition of his charges against Sir George Simpson may be wearisome, but there is no doubt that the action of the latter had been arbitrary, and in the words of the editor, "constitutes one of the most serious blots on his career."

The book contains interesting references to explorers such as Bonneville and Frémont, Edward Belcher, who later won fame in the search for Franklin, and Wilkes of the United States Exploring Expedition. And there are valuable pictures of Oregon in the years immediately before the boundary dispute was settled, while American settlers were pouring into the Willamette valley, and of California just before it was transformed by the gold rush of 1848.

Like other volumes in this series the work is well edited and produced. It is

to be regretted that a map was not included showing the forts of the Hudson's Bay Company. E. W. G.

GENERAL

AN INTRODUCTION TO POLLEN ANALYSIS. By G. ERDTMAN. (New Ser. of plant science books, vol. 12.) *Waltham, Mass.: Chronica Botanica Co.*, 1943 (*London: W. Dawson*). 10½×7 *inches; 240 pages; illustrations and diagrams.* $5

Pollen analysis is now firmly established as one of the most powerful weapons of the researcher into the climates, floras, and human cultures of interglacial and postglacial time. Its development as an important scientific method dates from a paper published by the Swedish botanist Lennart von Post in 1916. Large numbers of papers have since analysed and criticized all aspects of the technique and the assumptions on which it is based, and have described the vast body of data obtained by its use. A summary of this literature in convenient form is badly needed, and Dr. Erdtman's book supplies the need in part. His aim is limited to introducing the student to the technique of pollen analysis, to explaining its theoretical background, and to providing a valuable set of descriptions and figures of pollen grains. He does not attempt to review the results obtained in various fields by the use of the new method. That would require a vastly larger book, if not a series of volumes.

Pollen analysis involves the identification of pollen grains incorporated in materials such as peat, raw humus, lignite, marine and fresh water alluvium, and even honey. These grains are presumed to have blown at flowering time from trees growing in more or less close proximity to the collecting material. If then the collecting material is constantly being added to from above, as is usually true of peats and alluvia, the pollen grains caught each season in a new uppermost layer will provide a continuous record of the "pollen rain" during the whole period of collection. The scientific value of examining the grains at various depths below the surface depends then on two quite different factors. First, on the possibility of accurate identification; and second, on a firm basis for comparative interpretation.

After a brief introduction a chapter by the author's brother, Dr. H. Erdtman, deals with the chemistry of peat and shows how it is possible to treat a sample of peat so that pollen grains persist, with their characteristic form and surface features unchanged, even when most of the other plant remains have been dissolved or reduced to tiny colourless fragments. This is possible because of the high chemical stability of the waxy cutin which coats and impregnates the outer walls of pollen grains. The next two chapters describe techniques, largely devised by the author himself, for preparing microscopic slides which will enable the grains to be identified. Descriptions of the pollen grains of a wide variety of flowering plants and conifers follow, with a diagram of each. The diagrams are drawn to a uniform scale—a useful point—and give a very good impression of the form though a rather less satisfactory representation of the surface texture of the grains figured. These diagrams alone make the book a most valuable addition to the pollen analyst's library.

In the concluding chapters Dr. Erdtman faces the problems of the interpretation of the results of pollen analysis. What may safely be deduced when the identifications have been made? Are all types of pollen equally well preserved? Are they preserved in proportions reflecting the relative abundance in the neighbourhood of the trees from which they have been shed? To what extent is the nature of the pollen rain determined by nearby or by more distant trees? Do variations in their rate of sinking, their weight, and their transportability

affect their representation in the pollen rain? Dr. Erdtman has caught pollen grains in vacuum cleaners all across the Atlantic Ocean, and the results of his own researches are rightly prominent in this discussion. It becomes clear that great caution must be exercised in translating pollen data into statements about vegetational composition, and that the information summarized in this book will provide the basis for the further study required. Nevertheless the interpretation of the very regular changes in pollen composition in terms of climatic changes in postglacial time is beyond dispute, and Dr. Erdtman emphasizes, perhaps not strongly enough, the great importance of pollen diagrams in making stratigraphical correlations possible, quite independently of a detailed interpretation of the diagrams in terms of vegetational composition. Diagrams from deep peat deposits anywhere in Western Europe show such striking similarities in the behaviour of the pollen of the chief tree species, and such consistent correlations with archaeological and physiographical happenings, that their characteristic pattern provides for many researchers their main interest in pollen analysis. There are dangers in assuming too easily that similarity of pattern necessarily means contemporaneity of corresponding parts of the pattern, but how to assess and avoid the danger is rapidly being learned.

The book concludes with a tantalizingly brief chapter on the pollen analysis of honey, giving a glimpse of another and very different field full of interest for the biologist. A. R. C.

GEOGRAPHY OF AN AIR AGE. By E. G. R. Taylor. (Looking forward Pamphlets, No. 4.) *London: Roy. Inst. of Internat. Affairs*, 1945. 7×5 *inches; 56 pages; sketch-maps.* 1*s*

Within the limits of this short pamphlet, Professor Taylor has compressed lucidly many apposite facts and illuminating comments. It will enable the general reader, to whom it is addressed, to appreciate intelligently the geographical basis of air communications, and the changes in world relationships which their development may be expected to introduce. The first section states in non-technical terms the general problem involved in mapping the surface of the earth, discusses the merits and demerits of the globe and the Mercator chart, and explains the use of the azimuthal equidistant chart. The accompanying diagrams might have included lines of equal bearing. Use is also made later of the Transverse Mercator. The examples included show the distribution of urban concentrations of more than one million inhabitants, and the great circle route from Washington to Singapore. The features thus brought out cannot readily be appreciated on other projections. It is within the area shown on the former that the main trunk routes will lie. The advantages which London might derive from its proximity to the centre of the principal hemisphere are appropriately stressed. The influence of weather conditions, the position of bases, and payloads are then briefly indicated. The social importance of a network of air routes will be greatest in sparsely populated and undeveloped areas, but the weight of traffic will be heaviest on the routes between the great world centres, which will approximate to, but not necessarily coincide with, great circle courses. These are some of the interesting points briefly touched upon in this essay. All provoke thought, but not necessarily complete assent. It may be true, as an American geographer whom Professor Taylor quotes approvingly, asserts, that "the democratic nations have been most ungeographical in their thinking," but is this entirely true, as the remainder of the quotation implies, of their leaders? G. R. C.

ADDITIONS TO THE LIBRARY

This list contains books and periodicals for the most part received in the Library during 1945. *Inclusion in this list does not imply that a work has not been, or will not be, reviewed in the* Geographical Journal.

BRITISH ISLES

OUR HERITAGE OF WILD NATURE; a plan for organized nature conservation. By A. G. TANSLEY. 10×7. 74 pp. Illustrations. *Cambridge: Univ. Press.* 7*s* 6*d*

THE COMMONERS' NEW FOREST; an outline of the history of the New Forest, . . . its peasant pastoral industry and its possibilities. By F. E. KENCHINGTON. 8½×5½. 220 pp. Illustrations. *London: Hutchinson*, 1945. 12*s* 6*d*

THE FUTURE OF BRITISH FARMING. By A. W. MENZIES-KITCHIN. 9×5½. 64 pp. Illustrations. *London: Pilot Press*, 1945. 5*s*

AN INDUSTRIAL PLAN FOR WEST CUMBERLAND. By W. C. DEVEREUX. 9½×7. 68 pp. *Whitehaven*, 1944

RADNOR OLD AND NEW. By W. H. HOWSE. 8½×5½. 54 pp. Illustrations. *Hereford: Jakemans*, 1944

Notes on the history, legends, and folklore of a town of the Welsh March, with a glossary of dialect words used in Radnorshire. Though Welsh is no longer spoken, many relics of its construction and vocabulary can still be traced.

NATIONAL PARKS IN ENGLAND AND WALES. Report by JOHN DOWER. 9½×6. 57 pp. (Min. of Town and Country Planning.) *London: H.M.S.O.*, 1945. 1*s*

OILFIELDS IN GREAT BRITAIN. By G. M. LEES. (*Nature* 155 (1945) 567–9)

AERIAL RECONNAISSANCE OF THE FEN BASIN. By D. N. RILEY. Illustrations. (*Antiquity* 19 (1945) 145–53)

EUROPE

THE BALTIC NATIONS: Estonia, Latvia, and Lithuania. By F. W. PICK. 7½×5. 172 pp. *London: Boreas Publishing Co.*, 1945. 7*s* 6*d*

A history of these three states, emphasizing their development between 1919 and 1939, and a plea for the recognition of their independence.

CZECHOSLOVAKIA; land of dream and enterprise. By JAN ČECH and J. E. MELLON. 8½×5½. 184 pp. Illustrations and maps. *London: Czechoslovak Min. of Foreign Affairs*, 1944. 15*s*

An enthusiastic account of the people and their country, history, and industrial progress, with many illustrations.

AGRICULTURE AND FOOD IN THE NETHERLANDS. By L. E. BUTT. (*Foreign Agric.* 8 (1944) 225–40)

POLAND. Edited by BERNADOTTE E. SCHMITT. (The United Nations Series.) 8½×5½. 500 pp. Illustrations. *Berkeley, Cal.: Univ. of California Press*, 1945. 30*s*

U.S.S.R.; the story of Soviet Russia. By WALTER DURANTY. 8×5½. 294 pp. *London: Hamish Hamilton*, 1944. 15*s*

LENINGRAD. By ALEXANDER WERTH. 8×5½. 190 pp. Illustrations. *London: Hamish Hamilton*, 1944. 10*s* 6*d*

ETHNIC GROUPS IN CITIES OF THE SOVIET UNION. By C. D. HARRIS. (*Geogr. Rev.* 35 (1945) 466–73)

CONFERENCIA PRELIMINAR SOBRE LOS PUERTOS DE ESPAÑA. By M. MENENDEZ BONETA. (*Bol. R. Soc. Geogr. Madrid* 80 (1944) 45–69)

This number also contains several papers on individual ports of Spain.

ASIA

WINDS AND FRONTS OVER SOUTH-EAST ASIA. By E. H. G. DOBBY. (*Geogr. Rev.* 35 (1945) 204–18)

CRADLE OF SPLENDOUR; the song of Samarkand. By GEORGE BORODIN. $8\frac{1}{2}\times5\frac{1}{2}$. 200 pp. Illustrations. *London: Staples Press*, 1945. 15*s*

THE AGARIA. By VERRIER ELWIN. $8\frac{1}{2}\times5\frac{1}{2}$. 292 pp. Illustrations. *London: H. Milford*, 1942. 21*s*

HISTORY OF THE FRONTIER AREAS BORDERING ON ASSAM FROM 1883 TO 1941. By SIR ROBERT REID. $9\frac{1}{2}\times6\frac{1}{2}$. 304 pp. *Shillong: Assam Govt. Press*, 1942

THE HINDIYAH BARRAGE: its history, design, and function. By AHMED SOUSA. $9\times6\frac{1}{2}$. 100 pp. Illustrations and maps. *Baghdad: Govt. Press*, 1945

AFRICA

GEODESY IN EGYPT. By J. H. COLE. (Survey Dept. Papers.) Diagrams. 11×8. 164 pp. *Cairo*, 1944

THE POPULATION OF THE EGYPTIAN OASES. By M. MITWALLI. (*Bull. Soc. Géogr. Egypte* 21 (1945) 209–28)

LA VIE DANS LE HAUT-DELTA DU NIL. By J. LOZACH. (*Estudios Geogr., Madrid*, 5 (1944) 363–92)

SOILS IN RELATION TO NATIVE POPULATION IN WEST USUMBARA. By G. MILNE. (*Geography* 29 (1944) 107–13)

LE PAYSAGE RURAL AU MAROC. By J. CÉLÉRIER. (*Hésperis* (1943) 129–62)

An important paper on the methods of human geography, and their application to Morocco.

THE SOUTH AFRICAN UNION. $8\frac{1}{2}\times5\frac{1}{2}$. 220 pp. Illustrations. By LEWIS SOWDEN. *London: Robert Hale*, 1944. 15*s*

NORTH AND SOUTH AMERICA

CANADIAN NORTH. By MALCOLM MACDONALD. $7\frac{1}{2}\times5$. 268 pp. Illustrations. *Oxford: Univ. Press*, 1945. 10*s* 6*d*

An account of a journey through Canada north of the sixtieth parallel by the High Commissioner for the United Kingdom, written to assist in making Canadians conscious of the resources and possibilities of this territory.

BUILDING THE CANADIAN WEST; the land and colonisation policies of the Canadian Pacific Railway. By JAMES B. HEDGES. $8\frac{1}{2}\times6$. 422 pp. Maps. *New York: Macmillan Co.*, 1939

LE CANADA PAR L'IMAGE. By B. BROUILLETTE. 3rd ed. $9\frac{1}{2}\times6\frac{1}{2}$. 144 pp. Illustrations. *Montreal: Editions Beauchemin*, 1944. $1

This book is designed to arouse an interest in geography among young Canadians and to acquaint them with the main geographical features of their country. The text, written round the ninety-six illustrations, opens with a fairly detailed description of the site and development of Montreal, followed by shorter descriptions of the Province of Quebec and Canada as a whole.

THE NAVAHO DOOR; an introd. to Navaho life. By A. H. and D. C. LEIGHTON. $9\times6\frac{1}{2}$. 150 pp. Illustrations. *Cambridge, Mass.: Harvard Univ. Press* (*Oxford U.P.*), 1944

A COCKNEY ON MAIN STREET. By HERBERT HODGE. 8×5. 154 pp. *London: Michael Joseph*, 1945. 10*s* 6*d*

DAWN BREAKS IN MEXICO. By W. B. J. OSBALDESTON MITFORD. $7\frac{1}{2}\times5$. 228 pp. Illustrations. *London: Cassell*, 1945. 9*s*

An "attempt to correct many false impressions which exist about Mexico" by a member of the British Legation.

THE ISLES OF GUADELOUPE. By JEAN GOTTMANN. (*Geogr. Rev.* 35 (1945) 182–203)

REPORT ON EXPLORATION FOR OIL IN BRITISH GUIANA. By H. G. KUGLER and others. Maps. (*Geol. Survey Brit. Guiana Bull.* 20 (1944) 78 pp.)

AUSTRALIA, NEW ZEALAND

THE RELATIONSHIP OF THE AUSTRALIAN CONTINENT TO THE PACIFIC OCEAN. By W. H. BRYAN. (*J. and Proc. R. Soc. New South Wales* 78 (1944) 42–62)

THE SURVEY AND CLASSIFICATION OF LAND IN NEW ZEALAND. By K. B. CUMBERLAND. (*Trans. and Proc. R. Soc. New Zealand* 74 (1944) 188–95)

PHYSICAL GEOGRAPHY

SOME RECENT CONTRIBUTIONS TO THE STUDY OF CLIMATIC CHANGE. By GORDON MANLEY. (*Quart. Journ. R. Meteorol. Soc.* 70 (1944) 197–220)

SYMPOSIUM ON LOESS, 1944. Foreword by M. K. ELIAS. (*Amer. Journ. Science* 243 (1945) 225–303)

METEORITES AND SOME OF THE PROBLEMS WHICH THEY PRESENT. By LORD RAYLEIGH. (*Endeavour* 3 (1944) 127–34)

HUMAN GEOGRAPHY, ECONOMICS

PRINCIPLES OF ECONOMIC GEOGRAPHY. By ELLSWORTH HUNTINGTON, assisted by F. E. Williams, S. van Valkenburg, and S. S. Visher. 9×6. 716 pp. Sketch-maps and diagrams. *New York: John Wiley* (*London: Chapman and Hall*), 1940. $4

ENOUGH AND TO SPARE. By KIRTLEY F. MATHER. 7½×4½. 186 pp. Sketch-maps. *New York: Harper*, 1944. $2

LAND SETTLEMENT AND RESOURCE DEVELOPMENT. By ISAIAH BOWMAN. (*Nature* 155 (1945) 5–10)

THE CONDITION OF MAN. By LEWIS MUMFORD. 9½×6. 468 pp. *London: Martin Secker*, 1945. 25*s*

CLIMATE MAKES THE MAN. By CLARENCE A. MILLS. 7½×5. 186 pp. *London: Gollancz*, 1944. 7*s* 6*d*

CLIMATE, WEATHER, AND MAN. By DAVID BRUNT. (*Endeavour* 3 (1944) 87–97)

SYMPOSIUM ON FORESTRY AND THE PUBLIC WELFARE. (*Proc. Amer. Philos. Soc.* 89 (1945) 399–488)

THE GEOGRAPHY OF WORLD AIR TRANSPORT. By J. PARKER VAN ZANDT. (America faces the air age, vol. 1.) 9½×6. 68 pp. Diagrams. *Washington, D.C.: Brookings Institution*, 1944. 6*s*

GEOGRAPHY OF AN AIR AGE. By E. G. R. TAYLOR. ('Looking forward' pamphlets, No. 4.) 7×5. 56 pp. Sketch-maps. *London: R. Inst. Internat. Affairs*, 1945. 1*s*

THE THREE AGES; an essay on archaeological method. By GLYN E. DANIEL. 7½×5. 60 pp. *Cambridge: Univ. Press*, 1943. 3*s* 6*d*

GENERAL, BIOGRAPHY

CRUISES AND CARAVANS. By ELLA MAILLART. 8½×5½. 162 pp. Illustrations. *London: J. M. Dent*, 1943. 8*s* 6*d*

MORNING WILL COME. By GORDON WATERFIELD. 8½×5½. 198 pp. Illustrations. *London: John Murray*, 1944. 10*s* 6*d*

SIR AUREL STEIN, 1862–1943. By C. E. A. W. OLDHAM. (From *Proc. British Acad.*, *vol.* 29.) 10×6½. 20 pp. *London: H. Milford*, 1945

LIFE AND WORK OF JOHN TYNDALL. By A. S. EVE and C. H. CREASEY. 9×6. 404 pp. *London: Macmillan*, 1945. 21*s*

AMERIGO VESPUCCI, pilot major. By FREDERICK J. POHL. 9×6. 250 pp. Illustrations. *New York: Columbia Univ. Press* (*Oxford U.P.*), 1944. 20*s*

AMBER LIGHT; a formula for peaceful progress. By THORNBURN MUIRHEAD. 8½×5½. 190 pp. *London: Heath Cranton*, 1945.

The author expresses forcibly his views on the requirements of the reconstruction period, demanding the coordination and scientific planning of industry, public control of the financial system, and international cooperation for full employment.

THE STATESMAN'S YEARBOOK, 1945. Edited by M. EPSTEIN. 7×5. 1480 pp. Maps. *London: Macmillan*, 1945. 30*s*

THE MONTHLY RECORD

NORWEGIAN AWARDS

His Majesty The King has given permission for Mr. J. M. Wordie and Professor R. N. Rudmose Brown to wear the insignia of a Commander of the Order of St. Olav, and for Lieut.-Commander A. R. Glen, R.N.V.R., to wear the insignia of a Chevalier of the same Order, which were conferred on them by His Majesty King Haakon. The Awards were made for geographical exploration in the Arctic, particularly in the Norwegian territory of Svalbard.

THE HYDROGRAPHER OF THE NAVY

The war has made unprecedented demands upon the Hydrographic Department of the Admiralty, and it is common knowledge that the Hydrographer and his staff have been fully equal to the task. The work culminated with the successful landing in Normandy on D-day, in preparation for which it had been necessary to prepare new charts of the coast up to high-water line, under cover of night, through the enemy minefields and in the Assault Area. The surveying vessels and units carried out the sounding and danlaying to site the artificial harbours and the marking of convoy anchorages and approach channels. Admiral Sir Bertram Ramsay has expressed emphatically his appreciation of these achievements: "The Surveying Service were equal to every demand . . . and I have always held that one can place complete reliance on every branch of the Hydrographic organization." Throughout the war, this work has been directed by Vice-Admiral Sir John Edgell, K.B.E., C.B., F.R.S., who retired on April 30. Admiral Edgell succeeded Vice-Admiral Sir Percy Douglas as Hydrographer in 1932, so that his period of office has been the longest since Admiral Wharton's and much more strenuous. During these times, apart from the wartime activities, Admiral Edgell introduced notable advances in the Department. The change over from flat-bed direct to off-set printing, made possible by the completion of a new printing establishment in 1941, was particularly important in meeting the demand for charts during the war. Admiral Edgell has always promoted the study of the sea in all its aspects; he has been Chairman of the *Discovery* Ship Subcommittee, he has been largely responsible for the building and fitting out of the non-magnetic R.R.S. *Research*, and he has initiated steps to place oceanographical research in this country upon a permanent basis. Admiral Edgell is also the first Hydrographer for over thirty years to have been elected a Fellow of the Royal Society. His successor as Hydrographer of the Navy is Rear-Admiral A. G. N. Wyatt. J. M. W.

THE FORMER EXTENT OF AUSTRALIA

The Clarke Memorial Lecture for 1944 was delivered before the Royal Society of New South Wales on May 30 of that year by Dr. W. H. Bryan. The Rev. W. B. Clarke (1798–1878), whom the lectures commemorate, made some acute observations on the possible extension of Australia to the north-east in former geological times. Dr. Bryan therefore made the fitting choice of "The relationship of the Australian continent to the Pacific Ocean—now and in the past" (*J. and Proc. Roy. Soc. N.S.W.*, 78 (1944) 42–62) as the subject of his address. He begins by reviewing the accumulation of geological and seismological evidence in support of Suess' theory of the structural unity and permanence of the basin of the Pacific. He then turns to a review of the conflicting hypotheses on the former extent of continental land on the south-west margin of the Pacific, and accuses his fellow Australian geologists of insularity in their

approach to the problems involved. He considers that they confine their philosophical attention too closely to the present geographical limits of Australia; and their utter lack of interest in Schuchert's work of 1916 is certainly astonishing. "Schuchert saw Australia not as a stable unit achieved by constructive effort, but as the shrunken remnant of a disintegrated continent. Such a startling statement from one who was already recognized as a world authority on stratigraphy and palaeogeography would, one might expect, have caused a sensation in geological circles in Australia. It did not, as far as I can gather, create even a ripple," said Bryan. His own contribution is a very clear summary of recent geological and seismological work in Queensland, which shows that the Brisbane Schists probably accumulated in early Palaeozoic times, in a "mediterranean" geosyncline postulated by Schuchert, and that the floors of the seas east of Australia are seismically almost inert. From the whole field of evidence he concludes that the seismic zone of the island arcs from New Guinea to New Zealand is the hinge between a permanent Pacific ocean on the north-east and a disintegrating continental mass to the south-west.

A generalization involving the palaeogeography of a quadrant of a hemisphere must satisfy all conditions, from those of geophysics to those of biology. The first geophysical investigation carried out in Australia was the determination of the value of gravity at Sydney Cove, by the Spaniards in 1793. Since that time, geological and geomorphological study in Australia have proceeded without regard to gravity. The Dutch determinations of its value at sea, in the East Indies, should have aroused Australian interest, but the subject is not mentioned by Dr. Bryan. Nor does he give any space to the possible bearing of the Wegener hypothesis on the past relationships of Australia. Yet the late Launcelot Harrison, in a presidential address which is anything but insular ("The composition and origins of the Australian fauna, with special reference to the Wegener hypothesis," *Rep. Australasian Ass. Adv. Sci.*, 1926 (1928) 332–96), called this hypothesis "the only explanation . . . adequate to explain the [biological] divorcement between Asia and Australia." Nor is it enough to avoid insularity by looking far out to the north-east. To any one familiar with the geology of Western Australia, the western and southern margins of the continent are extremely puzzling.

The man in whose memory Dr. Bryan spoke, is called by the Royal Society, the Royal Society of New South Wales, the Australasian Encyclopaedia, and other authorities, the Rev. William Branwhite Clarke. But Henniker Heaton and the 'Australian Bibliography' calls him the Rev. William Branthwaite Clarke. As Branthwaite was undoubtedly the name of his residence at St. Leonards, North Sydney, the name Branwhite is open to question. If there is a mistake, it might well be corrected at the next Memorial Lecture. M. A.

ANCIENT AND MODERN ROUTES IN SINAI

'Abbas 'Ammar, author of a demographic survey of the Egyptian province of Sharqiya, has extended his researches farther east to the Sinai Peninsula. His monograph on "Egypt's Eastern Gate," "Al Madkhal al Sharqi li Misr" (*Bull. Soc. Roy. Géogr. Egypte* 221 (1945) 88), opens with a general appreciation of the geographical and economic factors which have influenced the history of the peninsula up to modern times, but it deals, in the main, with its topography and principal routes. For the historical geography before the Arab conquest, mainly European authorities are followed, and the most original portions of this study relate to the Islamic period.

During the Islamic period the relative importance of the ports of the region fluctuated considerably, trade mostly going to Qulzum and Suez up till the

tenth century, when they gradually gave place to Tor. About the mid-eleventh century 'Aidhab had largely superseded Tor, but, from the fourteenth century onwards, the latter port again recovered its pre-eminence. Sinai became more important during the Muslim era because one of the main pilgrimage routes (Darb al-Hajj) from North Africa passed through its territory; but with the extension of facilities for travel by sea in the nineteenth century, this route again reverted to a secondary importance.

The author divides the country into three distinct zones, coastal, central, and southern Sinai, treating of the main routes in each. He prefaces each section with a topographical and historical description of the zone, gives comparative tables of the stations on the routes discussed, from the itineraries preserved by classical, medieval Arabic, and more modern travellers and writers, and includes a topographical survey of the physical features and state of the roads at the present day.

In the northern zone 'Abbas 'Ammar points out the many ruins and evidences of land once irrigated, attempting to identify present ruins with stations figuring in the works of ancient and medieval writers. The three main routes described are: the Coast Road from Rafah to Pelusium; the Sand Road from 'Arish to al-Salihiya; and the road south of the sand-dune area to Ismailiya.

Nowadays the Sand Road is the principal route, whereas in medieval and earlier times it was the Coast Road that had the bulk of traffic. Indeed according to Maqrizi, the Sand Road was only discovered in the fifth century of the Hijra, but, as 'Ammar points out, this statement must be accepted with caution, and it may be that it only came into prominence about that time. Various reasons are suggested for the decline of the Coast Road, and it is significant that during the conquest of Egypt, the Sand Road was the route followed by the Arab armies.

Among other interesting suggestions, the author thinks that al-Farama (Pelusium), on the Coast Route, never recovered from its destruction by the Crusaders, especially as it is only after this event that Qatiya, a place not previously known, begins to appear in the itineraries which thenceforth run south of al-Farama. Identifications are given for the stations of al-Warrada and al-Baqqara which figure in the Arab geographers. Existing maps, 'Ammar says, do not show all the wells along the Sand Road which are quite frequent.

As contrasted with the other routes, the most southerly of the three (Darb al-Sham) is better going, but there are fewer wells to be found, though there are traces of artificial means of collecting water, such as cisterns of some antiquity.

Central Sinai has two main routes passing through it, leading from Egypt to the head of the Gulf of 'Aqaba, but they are only important after the Muslim conquest, and as pilgrimage routes. They are known as Darb al-Hajj and Darb al-Sha'wa, the latter lying roughly parallel and south of the former; both commence from Suez.

The Darb al-Hajj is in part sandy, a problem to motor traffic as the sand tends to drift on to the road, the pass down to 'Aqaba is extremely difficult to negotiate, and water is scarce also. Nakhl on this route is not known before the Turkish writer Hajji Khalifa, nor are the stations mentioned by the Arab geographers identifiable as belonging to it. On the other hand the little-known Darb al-Sha'wa, 'Ammar believes to be very ancient, and thinks it may be the route intended by the Arab geographers since most of the stations they mention are identifiable with places on this route which is also better supplied with water.

Owing to its remoteness southern Sinai derives little importance from the routes which traverse it, but it has a number of minerals such as copper, turquoise, and diorite. As a Christian religious centre it attracts a certain

amount of traffic, and parts are fertile. The three main external routes are discussed in rather less detail than those above; they are Suez–'Aqaba, Tor–Suez, Nabak–'Aqaba. R. B. S.

GEOLOGY IN EMBRYO

The early history of geology has often been discussed in a general way since Lyell devoted a few chapters to the subject in his 'Principles of geology.' Some writers have dealt with the observations made and the opinions expressed by ancient and medieval authors, and others have surveyed in broad outline the growth and application of knowledge concerning the structure of the earth and the processes which have given its surface the features with which we are familiar.

In "Geology in embryo (up to A.D. 1600)" (*Proc. Geol. Ass.* 56 (1945) 89) Mr. C. E. N. Bromehead sets out to supplement rather than to summarize what has already been written. As the author explains, many interesting passages that contain the germ of a geological idea, or even a surprisingly clear explanation of a geological phenomenon, have not up to now received the attention they deserve, while some of the well-known passages in early books have been misinterpreted or have been wrongly attributed.

For the geographer the most important sections of the paper are those dealing with the form of the earth, with explanations of the irregularities of its surface, and with earthquakes and volcanoes, but there is much in the sections dealing with fossils, minerals, and the stones used for building and decoration, which has a bearing upon the development and application of geographical knowledge.

We are reminded by extracts—some less well-known than others—from early writers that the Greeks had clear ideas upon the shape of the earth by the sixth century B.C., and that Strabo stressed the relative insignificance of the surface features which loom so largely in human thought, and to which even modern geologists are apt to accord an importance to which they are not entitled. Ovid made it clear that he thought of the earth as a spheroidal body kept poised in mid-air by its own rotation, and Herodotus was aware of the extent to which the materials of the dry land were transported by rivers and deposited in the sea.

Bearing in mind what has been written in recent years about soil erosion and its acceleration by unwise cultivation following the destruction of forests or other natural vegetation, it is interesting to find Plato writing of a time when mountains, which in his day were bare rocks and crags, were covered with soil, and recording that trees fit for the roofs of great buildings had been felled on mountains that, when he wrote, only supported bees (*i.e.* were covered with heather). In former times, he said, the rain water was received into and stored by the soil, instead of running off the barren ground to the sea.

In this, as in every other branch of the history of science, we are constantly reminded that ideas and suggestions which are often regarded as quite new, were recorded before the dawn of the Christian era, and one is led to wonder how much more rapidly knowledge of the laws and processes of Nature would have increased, if the history of the growth of knowledge had been regarded as an essential part of education.

There are some interesting accounts of contemporary records of the quarrying and preparation of stones for building and decoration by the ancients, and of saws fed with wet sand, or set with rectangular teeth of emery, which the Egyptians used for cutting stone; while the account of some early works dealing with mineralogy (which has, on the whole, a more extensive early literature than has geology in the strict sense), although brief, presents a well-balanced picture of the capacity for observation—and the credulity—which characterized

writers upon scientific subjects during the period with which the paper is concerned.

Scientific thought in Europe suffered eclipse after the sack of Alexandria in the seventh century A.D., and it is not until the sixteenth century that we find, especially in Italy, a number of authors whose works point to the emergence of geology as a separate subject. In 1517 for example Frascatore suggested that the Mosaic deluge could not be held responsible for the fossils found in the rocks at Verona because the "inundation was too transient and consisted principally of fluviatile waters, and if it had transported shells to great distances must have strewed them over the surface, not buried them at vast depths in the interior of mountains."

An outstanding figure in France in the sixteenth century was Bernard Palissy, the potter; there are some who think that he has received more than his due as a ceramic artist, but, as naturalist and geologist, he has had less. The value of his work lies principally in the fact that the ideas he expressed were his own and were based upon personal observation and practice. If some of what was written nearly two centuries later by many who sought to propound a "Theory of the Earth," is recalled, the calibre of Palissy's work can be gauged by his statement that in some cases "well waters may rise above the point at which the auger meets them, provided that there is a bed of marl that has been pierced and that the water comes from a place higher than the bottom of the hole you have made." He understood and clearly described the nature of artesian wells.

There is unfortunately very little that the author could say about contributions to geological knowledge made in Britain before the end of the sixteenth century. Perhaps the most important were the observations about the distribution of the Carboniferous Limestone and the associated coal in South Wales, made in the closing years of the sixteenth century by George Owen. These show that his knowledge was detailed and accurate enough to have enabled him to produce a geological map of the area, had suitable topographical maps been available.

The paper ends with an extensive bibliography of ancient and modern authors, the value of which is increased by references to reliable modern texts for the former.

F. J. NORTH

VISIT TO GOUGH ISLAND

We are informed by Mr. Allan Crawford that he anticipated sailing during October from South Africa on a short visit to Gough Island in the South Atlantic and to Marion Island in the South Pacific. Mr. Crawford is a member of the Meteorological Section of the South African Air Force, and the purpose of his visit is to examine the possibility of establishing meteorological stations on the islands. In 1937–38 he was attached as surveyor to the Norwegian scientific expedition which spent four months on Tristan da Cunha, and on the return voyage to Simonstown he landed for a short time on Gough Island. Little is known of this uninhabited island, which has had few visitors apart from the Scottish National Expedition in 1904 and Shackleton's *Quest* in 1922. From his experiences as meteorological observer on Tristan da Cunha during the war, Mr. Crawford appreciated the value for weather forecasting in South Africa of reliable reports from stations in the South Atlantic, and of simultaneous observations on Gough Island and Marion Island. His proposals for this reconnaissance received the support of the Forecasting and Research Sections and the approval of the Government of the Union. He also hopes to secure colour films of the islands.

CORRESPONDENCE

SURVEY IN THE LIBYAN DESERT

I am very much interested by some of Captain J. W. Wright's notes on map making and survey in the Libyan Desert (pp. 100–111, March–April *Journal*, 1945), especially on methods adopted. He, as many others in desert map making, has combined any method which was suitable and came readily to hand in his traverses. But two conclusions in particular interest me because they accord so very closely with my own experience and practice of twenty-five years ago when I was making maps by camel journeys in the Sahara. In the first place Captain Wright, as I did, used primarily astronomical fixes by pairs of E.–W. and N.–S. stars for longitude and latitude with stop watch, half chronometer and wireless time corrections before and after sets of observations, in preference to other sets of sights and computations. Secondly he emphasizes the desirability of computing, plotting, and working up results immediately in the field, without prejudice to revision and re-plotting later in the office. I am quite sure that any reasonably good results which can be obtained by rough and rapid survey of this sort, are secured in the manner described, that is by working up and plotting in the field, immediately and by the person concerned in the work himself. I hope that in all expeditions in which the Society is interested in the future, it will insist on such field work being undertaken by members of the parties engaged in survey and map work. I agree that most of the inaccuracies in Italian maps probably come from too little field work and too much office "working up"; I also agree that a great deal of work in adjustment is avoided by following Captain Wright's precepts. But the method involves much hard work under trying conditions.

RENNELL

10 *October* 1945

CYRENAICA

The future of Cyrenaica and of the other Italian colonies is one of the problems awaiting international settlement. Cyrenaica deserves special consideration, because its people have been our allies. When in 1940 France collapsed and Italy entered the war al-Sayyid Muhammad Idris, Head of the Sanusiya religious order and leader of the Sanusis (Senussis) of Cyrenaica, at once offered to the British military authorities in Cairo the services of himself and of his people. The Sayyid had been for close on twenty years an admirer of Great Britain and a bitter enemy of the Italians who had devastated his country and driven him into exile, so his offer might have been expected; but it should always be remembered to the credit of the Sanusis that it was made at the darkest hour of the war. The offer was gladly accepted and what was then called the British-Arab force, formed out of Sanusi exiles in Egypt, came into being under British officers and performed considerable ancillary duties, to which Mr. Eden paid tribute in the House of Commons on 8 January 1942. The Beduin of Cyrenaica also gave valuable help to escaped British prisoners and men detached from their units during our two withdrawals to Egypt.

It was not of their own choice that the Sanusi Beduin of Cyrenaica were so intimately involved in two European wars. They have always shown themselves anxious to keep out of disputes of other people. In the recent campaign in North Africa Rommel could use Cyrenaica as a base from which to attack Egypt because the Italians had developed the country with that end in view.

After 1912, when Turkey made peace with Italy and evacuated Tripolitania

and Cyrenaica, the Beduin of Cyrenaica, under the leadership of the Sanusiya order, continued to resist with such determination that the Italians were glad to sign a truce with their leader al-Sayyid Muhammad Idris in 1917. There followed five years of uneasy calm in Cyrenaica with the Italians in possession of the towns and the Sayyid's influence dominant in the rest of the country. It was broken when the Fascists came into power in 1922 and decided to end equivocation in their dealings with the Sayyid and to complete the conquest of the Colony. It took them ten years to do so though they brought against the Beduin all the weapons of modern warfare and used them with a ruthlessness which blackened for ever the name of Italy in all Arab and Muslim lands. Graziani finally crushed resistance in 1932 with the capture and public execution of the heroic guerrilla leader Umar al-Mukhtar.

The Italian colonial war in Cyrenaica was disastrous to the Beduin who are three-quarters of its population, at the present time about one hundred and fifty thousand, the other fifty thousand being townsmen. About half the Beduin were killed in the fighting, died from starvation and disease as a result of it, died in concentration camps, or fled to Egypt and other Near Eastern countries, while the flocks and herds on which they lived were almost exterminated. Their conquest completed, the Italians began to develop the country rapidly to the benefit of their own nationals. They planted metropolitan colonies, built villages and roads and railways, improved the ports, and made airfields. Their intention was to make Cyrenaica a part of Italy, and in 1939 it was formally incorporated in the Kingdom. The colonization of the two Libyan colonies of Tripolitania and Cyrenaica was part of a wider plan which included the acquisition of Tunisia, which the Italians had long coveted, and Egypt, which lay between their North African and East African possessions. They therefore concentrated in their development of Cyrenaica on strategic requirements to the detriment of the political and economic needs of the Colony.

Since El 'Alamein the country has been administered by a British Military Government, whose task has been much simplified by the withdrawal of all Italian colonists shortly before our decisive break-through in the Western Desert and by the goodwill of the Arabs, Beduin and townsmen alike. The Arabs have willingly accepted minor privations as part of their contribution to the Allied war effort and they have understood that the British Government could not, while the war was in progress, be more precise about their future than Mr. Eden's promise in the House of Commons that the Sanusis of Cyrenaica should not again come under Italian rule at the end of the war. They now await a more positive statement.

There can be no doubt about the wishes of the population. The entire country follows al-Sayyid Muhammad Idris, whose grandfather founded the Sanusiya religious order to which most of it adheres, and expects him to be its Amir and titular head of its government. Nevertheless, the Arabs realize that they could not protect, administer, and develop their country without outside help, and they hope that they may be placed under the mandate of a sympathetic power on the model of Transjordan, and they would prefer this power to be Great Britain, whose interests are so closely bound up with those of the whole Arab world and who has no colonial ambitions to satisfy. They would certainly regard any attempt at colonization as a betrayal. Cyrenaica is an Arab and Muslim country and has no minority problems. It would be foolish to make them. Also, the land suitable for agriculture and stock raising would be insufficient for both the Arabs and for foreign immigrants once the Arabs have repaired the heavy losses in manpower and stock they suffered at the hands of the Italians. The Italians towards the end of their period of rule, when they

were trying to conciliate the Arabs, recognized that they are not only competent shepherds, but can also be competent agriculturalists as well, and began to build farms and villages for them on the model of their metropolitan settlements. Moreover, the Arabs are to-day working the evacuated Italian farms under British supervision. Finally, the people of Cyrenaica accept that there are good historical and political reasons why the future of their country must be discussed separately from the future of Tripolitania. They would like to see them come under the same control, but if this is impossible they would probably ask for a rectification of the frontier the Italians made between the two parts of their Libyan Colony so that the followers of al-Sayyid Muhammad Idris in the Sirtica might be included in Cyrenaica. E. E. EVANS-PRITCHARD

16 *October* 1945

MEETINGS: SESSION 1944–45

Twelfth Meeting, 5 March 1945. The President in the Chair

Geographical Films: North-west Greenland and North Baffin Island. Commentary by Mr. J. M. Wordie

Thirteenth Meeting, 12 March 1945. The President in the Chair

Elections: Frederick Thomas Allen; Alfred William Beach; Lieut. R. M. Beardson, R.N.V.R.; Surgeon-Commr. Edward William Bingham, R.N.; Lieut.-Commr. James Albert Brown, R.C.N.R.; Hector Edward Bull; Mrs. Mildred Denys-Burton; Saroj Ranjan Chaudhuri; Ronald James Harrison Church, B.SC., PH.D.; Kenneth de Burgh Codrington, M.A., M.R.A.S., F.R.A.I.; Squadron-Leader A. G. Dunlop-Mackenzie; Eric Allsop Garratt, M.R.S.T.; William Greville, Jnr.; Arnold Houghton, A.M.I.P.E.; Bob Jones, M.A., D.LITT., L.H.D., LL.D.; Reginald Killey; Lieut. George Moore McClorry, R.N.R.; George Norman Martin, R.N.; Arthur Edmund Niblett; John Richard North; Kenneth David Salmond; Captain John Alastair Livingston Timpson; E. Travers-Smith; Joshua Austin Turner

Paper: Northern Highway of Peru. By Mr. Christopher Sandeman

Fourteenth Meeting, 26 March 1945. The President in the Chair

Paper: Zones of rock flow and resulting land forms. By Dr. S. E. Hollingworth

Fifteenth Meeting, 16 April 1945. The President in the Chair

Elections: Miss E. Allis-Smith; The Rev. James Reginald Balsdon, M.A., M.R.S.T.; Thomas John Bennett; S. A. Billinghurst, B.SC., PH.D.; Major Charles William Cousland, R.E.; Miss M. Coxon; Kenneth Wynne Enion; George Max Flemming, M.A., M.R.C.S., L.R.C.P.; David Henry Leonard Flinn; Squadron-Leader Ronald Hewitt, M.SC., R.A.F.; John P. Love; General J. J. H. Nation, C.V.O., D.S.O.; Eric Ivor Peddle; George Charles de Fraine Roffey; Captain F. C. P. Slinger, I.E.; Major William Maynard Younger, M.B.E.

Paper: Szechwan during the war. By Dr. H. L. Richardson

Sixteenth Meeting, 23 April 1945. The President in the Chair

Geographical Films: Enthronement of the Dalai Lama, and journeys in Bhutan. Kodachrome films by Sir Basil Gould. With commentary by Colonel F. M. Bailey

Seventeenth Meeting, 30 April 1945. Field-Marshal Sir Philip Chetwode, vice-President, in the Chair.

Paper: Progress of soil conservation in the United States. By Mr. Russell Lord

ANNUAL GENERAL MEETING, 25 June 1945. The President, The Right Hon. Sir GEORGE CLERK, in the Chair.

The HON. SECRETARY (Mr. J. M. Wordie) read the Minutes of the Annual General Meeting held on 19 June 1944, which were confirmed and signed by the President.

The PRESIDENT said: As I explained in my address to the Annual General Meeting last year, it is not yet possible to assess the relative value of the geographical work done in the course of military duty by officers of His Majesty's Forces, and for this among other reasons the Council have, for the last two years, deemed it proper to ask permission of His Majesty the King to postpone the submission of recommendations for the Royal Medals, and have also postponed the grant of the other Awards of the Society. The Council have however been conscious that, in so doing, they might find that the opportunity of honouring the work of distinguished senior British geographers was being allowed to pass. Accordingly, they resolved this year, while adhering in principle to their earlier decision, to submit to His Majesty a recommendation for one of the Gold Medals, and I am happy to say that His Majesty The King has approved the award of the Patron's Medal for 1945 to Sir Halford Mackinder.

Sir Halford's distinguished service to geography is so well known to all geographers that to dwell upon it in detail would be superfluous. Both "in the field and in the study," to quote from the title of his address to this Society on the occasion of the Jubilee of His Majesty King George V, he has won high distinction. By his first ascent and survey of Mount Kenya in 1899, his name is established in the history of African exploration. At Oxford and later in the University of London, he has inspired and guided successive generations. But to him geography has been not merely the concern of the schools: he has striven to secure the recognition of its fundamental role in national life, and its value as a bridge between science and philosophy. To many, his 'Britain and the British seas' has revealed for the first time the fascinating interplay of environment and human society. As a political geographer his reputation is indeed world wide.

In handing to you, Sir Halford, this certificate in anticipation of the Medal itself which awaits, like much else, the release of gold, I ask you, on behalf of the Council and the Society, to accept our very cordial recognition of your distinguished labours in the advancement of geography.

Sir HALFORD MACKINDER: I am fully conscious, Mr. President, that it is an exceptional honour that, with the approval of His Majesty The King, you have to-day conferred upon me in presenting to me this Patron's Medal. If it has fallen to me alone to be thus recognized, I realize that it is as survivor of a small group of men who a generation and rather more ago, here in London and a few of them in Scotland, achieved a revolution in the conception of geography in this country. My old friend, Hugh Robert Mill, a former Librarian of this Society, is the only other of that group that I am aware of as still living.

I noted with special pleasure the terms of the formal award, and no less of your remarks, Sir, just now. In both alike the exploration of Mount Kenya is central, but the years that preceded and that succeeded are not forgotten. I cannot do better than appropriate your words: it was in the closing decades of last

century that a rational geography became "the concern of the schools" and Universities, and in the opening decades of the present century that "its fundamental role in national life and its value as a bridge between science and philosophy" were recognized.

In the spring of 1886 I one day received a letter from Henry Walter Bates, the famous naturalist on the Amazon, who was then Assistant Secretary of this Society. He asked me, a young graduate just down from Oxford, to call on him in Savile Row. There he told me that Francis Galton, then one of our Honorary Secretaries, had heard of some University Extension lectures I had been giving under the title of "The new geography." Bates asked that I should write down what I meant by that expression. A Scottish journalist, Keltie, was at that same time being sent by our Society to report on the teaching of Geography in the leading countries of the European continent. He returned with a remarkable collection of wall-maps, which were exhibited in London in the midwinter of 1885–86, and aroused considerable public interest. My paper on "The scope and methods of geography," prepared in response to Bates's request, was read at an evening meeting of this Society in February 1887. It was followed by an important debate in a full house, due not only to Keltie's and my activities, but also to the fact, that unknown to me at the time, the Council of the Society was divided into embattled parties with rival programmes. The progressives were led by Douglas Freshfield, Francis Galton, and Clements Markham, and in the end they won. As a result I was sent back to Oxford in June 1887 to inaugurate the teaching of Geography there on a pittance subscribed partly by the Society and partly by the University. Cambridge followed suit a couple of years later.

Twelve years elapsed before my Kenya year, 1899, and through that time a class was gradually built up, until it included undergraduates from every College in Oxford. As President of the Geographical Section of the British Association in 1895 I pleaded for the organization of a School of Geography, with an adequate staff of teachers and the necessary apparatus. This was arranged, and I was given leave of absence to visit East Africa, because at that time most people would have had no use for a geographer who was not an adventurer and explorer. I spent the long vacation of 1898 climbing in the Alps, and the opening weeks of 1899 preparing not only for my trip to the tropics, but also for the opening of the Oxford School of Geography in the autumn. One day a rumour reached me that a young Scottish geographer, Herbertson, a disciple of Patrick Geddes, on whom I had had my eye for my principal assistant, had been offered a professorship in New York, which he was about to accept. There and then I jumped into a train from Oxford to London, and thence took the night express on to Edinburgh. In the morning I breakfasted with Bartholomew, the great cartographer, and finding that he had as high an opinion of Herbertson's geography as I had, I drove to Collinton where Herbertson had his home. After lunch, when we were both in favourable moods, I told him that he was not going to New York, but was coming to me at Oxford in the autumn—and he came.

Douglas Freshfield, ex-President of the Alpine Club, found two experienced guides whom he persuaded to go with me from the foot of Mont Blanc to scale a peak in Equatorial Africa. In support of the climbing party there went two collectors recommended by the Natural History Museum at South Kensington. Campbell Hausburg, as second in command, shared with me the cost of the expedition; he was a remarkable shot with a rifle and an expert photographer. Our project was kept a secret, for I had no wish to find myself competitor in a race up a virgin peak. Kilimanjaro, a little higher than Kenya, had recently been climbed by a German, and it was likely that the idea of

climbing Kenya was in the air. Few people yet realized the contrast presented by the two summits, the higher a great dome with a crater filled with ice and snow, inviting a walk up; the other demanding a long clamber over crags and across hanging glaciers. I need not tell you how these difficulties were surmounted. All that is on printed record.

So we reach the third, the post-Kenya statement of the award and of your remarks, Sir. Herbertson proved to be a most admirable colleague. I remained six more years at Oxford and then left him as my successor. Via the geographical chair in the London School of Economics I passed gradually into spheres of wider experience. Now and again, in essays and addresses, and in a book, it became my privilege to write on the bridge function of geography in spanning the interval between scientific and political facts and philosophical values.

I do not think I need say more, but I wanted to put this much on record, because I realize that this Medal is a recognition by the Society of a success—may I say of a triumph—largely the result of the cooperation of men who are now gone, and whom it is my happy duty to-day to commemorate.

The PRESIDENT then delivered the Address printed on pp. 153–58. Visitors having withdrawn, the PRESIDENT appointed Dr. N. A. Mackintosh and Dr. G. C. Bertram to act as Scrutineers of the ballot for the election of the Council and Officers for the ensuing year.

The ballot was then taken and the Scrutineers withdrew.

The PRESIDENT, in submitting the Annual Report of the Council, said: If any Fellow of the Society has any observations to make on the Report which has been circulated we should be pleased to hear them.

The Annual Report was adopted without comment.

On the return of the Scrutineers the PRESIDENT announced their report that the candidates proposed by the Council had been unanimously elected (see list, volume prelim. following title page).

The PRESIDENT: I thank the Scrutineers for the trouble they have taken and, with that, we conclude the business of the meeting.

The LORD RENNELL OF RODD: Before you leave the hall, ladies and gentlemen, I feel sure you would like me to express on your behalf, the thanks of the Society to Sir George Clerk for the years of his presidency, years of no small difficulty, during which he has not only kept the activities of the Society before the world, but has also maintained the financial position of the Society, in spite of the decrease in the Fellowship. It is that accumulated reserve which will enable the Society, I hope, in the years which are to come to fulfil its functions on the lines of which Sir George Clerk has spoken and, indeed, which Sir Halford Mackinder described as having been begun fifty years ago.

I am very conscious of the burden which falls upon me in succeeding Sir George Clerk, but so long as I have the advantage of his support and that of the members of the Council who have given so much work to the Society, I feel, in some small measure, comforted. Sir George Clerk has done in these war years something which you will only realize later on. When other Societies have declined in activity and have had, practically speaking, to shut down, the President, with the Council, decided, in common with Government offices and the heads of the State in this country, to remain in the capital in spite of enemy action and to carry on. That decision was, in large measure, due to the President. It is therefore on that account and for his work that I would like on your behalf to offer him our very special thanks and admiration.

The PRESIDENT: Thank you all very much. I am fully rewarded by your appreciation for anything I may have been able to do during these past years.

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